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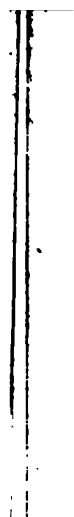
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*By contemplating the works of creation, man
rises to some faint idea of its great Author. N° 62.*

THE
Contemplative Philosopher:

OR
SHORT ESSAYS

ON THE
VARIOUS OBJECTS OF NATURE

NOTICED THROUGHOUT THE YEAR;

WITH
POETICAL ILLUSTRATIONS,

AND
MORAL REFLECTIONS ON EACH SUBJECT.

BY RICHARD LOBB.

Fourth Edition, Corrected and Improved.

.....
IN TWO VOLUMES.

VOL. II.
.....

London:

**PRINTED FOR SHERWOOD, NEELY, & JONES,
PATERNOSTER-ROW.**

1817.



Printed by T. Davison, Lombard-street, Whitefriars, London.

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THE
CONTEMPLATIVE PHILOSOPHER.

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No. XXXIX.

ON THE WONDERFUL INGENUITY OF  
WASPS.

The laws of life, why need I call to mind,  
Obeyed by *insects too* of every kind?  
Of these, none uncontrolled and lawless rove,  
But to some destined end spontaneous move:  
Led by that instinct Heav'n itself inspires,  
Or so much reason as their state requires:  
See all with skill acquire their daily food,  
All use those arms which Nature has bestowed;  
Produce their tender progeny, and feed  
With care parental, while that care they need:  
In these loved offices completely blest,  
No hopes beyond them, nor vain fears molest.

JENYNS.

THE wonders of Nature in the insect tribes are not confined to what is observable in the operations of bees. The labours of wasps, though not beneficial to mankind, are not less ingenious and worthy of admiration.—Wasps, like the bees, associate in great numbers, and construct a common habitation with much dexterity and skill. There are many species of wasps, some of which unite into societies,

and others spend their lives in perfect solitude. But I shall confine my attention to the operations of the common associating wasp, an insect so well known, even to children, that it requires no description. Though bees, as well as wasps, are armed with a sting, yet the former may be regarded as a placid and harmless race. Bees are continually occupied with their own labours. Their chief care is to defend themselves; and they never take nourishment at the expense of any other animal. Wasps, on the contrary, are ferocious animals, that live entirely on rapine and destruction. They kill and devour every insect that is inferior to them in strength. But, though warlike and rapacious in their general manners, they are polished and peaceable among themselves. To their young they discover the greatest tenderness and affection. For their protection and conveniency no labour is spared; and the habitations they construct do honour to their patience, their address, and sagacity. Their architecture, like that of the honey-bee, is singular, and worthy of admiration; but the materials employed furnish neither honey nor wax. Impelled by an instinctive love of posterity, with great labour, skill, and assiduity, they construct combs, which are composed of hexagonal or six-sided cells. Though these cells are not made of wax, they are equally proper for the reception of eggs, and for affording convenient habitations to the worms which proceed from them, till their transformation into wasps.

In general, the cells of the wasps are formed of a kind of paper, which, with great dexterity, is fabricated by the animals themselves. The number of combs and cells in a wasp's nest is always proportioned to the number of individuals associated. Different species choose different situations for building their nests. Some expose their habitations to all the injuries of the air; others prefer the trunks of de-

cayed trees; and others, as the common kind, conceal their nests under ground. The hole which leads to a wasp's nest is about an inch in diameter. This hole is a kind of gallery mined by the wasps, is seldom in a straight line, and varies in length from half a foot to two feet, according to the distance of the nest from the surface of the ground. When exposed to view, the whole nest appears to be of a roundish form, and sometimes above twelve inches in diameter. It is strongly fortified all round with walls or layers of paper, the surface of which is rough and irregular. In these walls, or rather in this external covering, two holes are left for passages to the combs. The wasps uniformly enter the nest by one hole, and go out by the other, which prevents any confusion or interruption to their common labours.

This subterraneous city, though small, is extremely populous. Upon removing the external covering, we perceive that the whole interior part consists of several stories or floors of combs, which are parallel to each other, and nearly in a horizontal position. Every story is composed of a numerous assemblage of hexagonal cells, very regularly constructed with a matter resembling ash-coloured paper. These cells contain neither wax nor honey, but are solely destined for containing the eggs, the worms which are hatched from them, the nymphs, and the young wasps till they are able to fly. Wasps' nests are not always composed of an equal number of combs. They sometimes consist of fifteen, and sometimes of eleven only. The combs are of various diameters. The first, or uppermost, is often only two inches in diameter, while those of the middle sometimes exceed a foot: the lowest are also much smaller than the middle ones. All these combs, ranged like so many parallel floors or stories above each other, afford lodging to prodigious numbers of inhabitants. Beau-



mur computed, from the number of cells in a given portion of comb, that, in a middle-sized nest, there were at least 10,000 cells. This calculation gives an idea of the astonishing prolific powers of these insects, and of the vast numbers of individuals produced in a single season from one nest; for every cell serves as a lodging to no less than three generations. Hence a moderate-sized nest gives birth annually to 30,000 young wasps.

The different stories of combs are always about half an inch high, which leaves free passages to the wasps from one part of the nest to another. These intervals are so spacious, that, in proportion to the bulk of the animals, they may be compared to great halls, or broad streets. Each of the larger combs is supported by about fifty pillars, which at the same time give solidity to the fabric, and greatly ornament the whole nest. The small combs are supported by the same ingenious contrivance. These pillars are coarse, and of a roundish form. Their bases and capitals, however, are much larger in diameter than toward the middle. By the one end they are attached to the superior comb, and by the other to the inferior. Thus, between two combs there is always a species of rustic colonnade. The wasps begin at the top and build downward. The uppermost and smallest comb is first constructed. It is attached to the superior part of the external covering. The second comb is fixed to the bottom of the first; and, in this manner, the animals proceed till the whole operation is completed. The connecting pillars are composed of the same kind of paper as the rest of the nest. To allow the wasps entries into the void spaces, roads are left between the combs and the external covering.

Having given a general idea of this curious edifice, it is next natural to inquire how the wasps build, and how they employ themselves in their

abodes. But, as all these mysteries are performed under the earth, it required much industry and attention to discover them. By the ingenuity and perseverance of Reaumur, however, we are enabled to explain some parts of their internal economy and manners. This indefatigable naturalist contrived to make wasps, like the honey-bees, lodge and work in glass-hives. In this operation he was greatly assisted by the ardent affection which these animals have for their offspring; for he found, that, though the nest was cut in different directions, and though it was exposed to the light, the wasps never deserted it, nor relaxed in their attention to their young. When placed in a glass-hive, they are perfectly peaceable, and never attack the observer, if he calmly contemplate their operations; for they do not sting, unless they are irritated.

Immediately after a wasp's nest has been transported from its natural situation, and covered with a glass-hive, the first operation of the insects is to repair the injuries it has suffered. With wonderful activity they carry off all the earth and foreign bodies that may have accidentally been conveyed into the hive. Some of them are occupied in fixing the nest to the top and sides of the hive by pillars of paper similar to those which support the different stories or rows of combs; others repair the breaches it has sustained; and others fortify it, by augmenting considerably the thickness of its external cover. This external envelope is an operation peculiar to wasps. Its construction requires great labour; for it frequently exceeds an inch and a half in thickness, and is composed of a number of layers as thin as paper, between each of which there is a void space. This cover is a kind of box for inclosing the combs, and defending them from the rain which occasionally penetrates the earth. For this purpose it is admirably adapted. If it were one solid mass, the con-

tact of water would penetrate the whole, and reach the combs. But, to prevent this fatal effect, the animals leave considerable vacuities between each vaulted layer, which are generally fifteen or sixteen in number. By this ingenious piece of architecture, one or two layers may be moistened with water, while the others are not in the least affected.

The materials employed by wasps in the construction of their nests are very different from those made use of by bees. Instead of collecting the farina of flowers, and digesting it into wax, the wasps gnaw with their two fangs, which are strong and serrated, small fibres of wood from the sashes of windows, the posts of espaliers, garden-doors, &c. but never attempt growing or green timber. These fibres, although very slender, are often a twelfth part of an inch long. After cutting a certain number of them, the animals collect them into minute bundles, transport them to their nest, and, by means of a glutinous substance furnished from their own bodies, form them into a moist and ductile paste. Of this substance, or *papier maché*, they construct the external cover, the partitions of the nest, the hexagonal cells, and the solid columns which support the several layers or stories of combs.

The constructing of the nest occupies a comparatively small number of labourers. The others are differently employed. Here it is necessary to remark, that the republics of wasps, like those of bees, consist of three kinds of flies; males, females, and neuters. Like the bees, also, the number of neuters far surpasses that of both males and females. The greatest quantity of labour is devolved upon the neuters; but they are not, like the neuter bees, the only workers; for there is no part of their different operations which the females, at certain times, do not execute. Neither do the males, though their *industry is not comparable* to that of the neuters,



remain entirely idle. They are often occupied in the interior part of the nest. The greatest part of the labour, however, is performed by the neuters. They build the nest, feed the males, the females, and even the young. But while the neuters are employed in these different operations, the others are abroad in hunting parties. Some attack with intrepidity live insects, which they sometimes carry entire to the nest; but they generally transport the abdomen or belly only: others pillage butchers' stalls, from which they often arrive with a piece of meat larger than the half of their own bodies: others resort to gardens, and suck the juices of fruits. When they return to the nest, they distribute a part of their plunder to the females, to the males, and even to such neuters as have been usefully occupied at home. As soon as a neuter enters the nest, it is surrounded by several wasps, to each of whom it freely gives a portion of the food it has brought. Those who have not been hunting for prey, but have been sucking the juices of fruits, though they seem to return empty, fail not to regale their companions; for, after their arrival, they station themselves upon the upper part of the nest, and discharge from their mouths two or three drops of a clear liquid, which are immediately swallowed by the domestics.

The neuter wasps, though the most laborious, are the smallest; but they are extremely active and vivacious. The females are much larger, heavier, and slower in their motions. The males are of an intermediate size between that of the females and neuters. From these differences in size, it is easy to distinguish the different kinds of those wasps which build their nests below the ground. In the hive of the honey-bee, the number of females is always extremely small; but in a wasp's nest there are often more than three hundred females. During the

months of June, July, and August, they remain constantly in the nest, and are never seen abroad except in the beginning of spring, and in the months of September and October. During the summer, they are totally occupied in laying their eggs and feeding their young. In this last operation, they are assisted by the other wasps; for the females alone, though numerous, would be insufficient for the laborious task. A wasp's nest, when completed, sometimes consists of sixteen thousand cells, each of which contains an egg, a worm, or a nymph. The eggs are white, transparent, of an oblong figure, and differ in size, according to the kind of wasps which are to proceed from them. Some of them are no larger than the head of a small pin. They are so firmly glued to the bottoms of the cells, that it is with difficulty they can be detached without breaking. Eight days after the eggs are deposited in the cells, the worms are hatched, and are considerably larger than the eggs which gave birth to them. These worms demand the principal cares of the wasps that continue always in the nest. They feed them, as birds feed their young, by giving them, from time to time, a mouthful of food. It is astonishing to see with what industry and rapidity a female runs along the cells of a comb, and distributes to each worm a portion of nutriment. In proportion to the ages and conditions of the worms, they are fed with solid food, such as the bellies of insects, or with a liquid substance disgorged by the mother. When a worm is so large as to occupy its whole cell, it is then ready to be metamorphosed into a nymph. It then refuses all nourishment, and ceases to have any connexion with the wasps in the nest. It shuts up the mouth of its cell with a fine silken cover, in the same manner as the silkworm and other caterpillars spin their cods. This operation is completed in three or four hours, and the animal re-

mains in the nymph state nine or ten days, when, with its teeth, it destroys the external cover of the cell, and comes forth in the form of a winged insect. In a short time, the wasps newly transformed receive the food brought into the nest by the foragers in the fields. What is still more curious, in the course of the first day after their transformation, the young wasps have been observed going to the fields, bringing in provisions, and distributing them to the worms in the cells. A cell is no sooner abandoned by a young wasp, than it is cleaned, trimmed, and repaired by an old one, and rendered, in every respect, proper for the reception of another egg.

As wasps of different sexes differ greatly in size, they know how to construct cells proportioned to the dimensions of the fly that is to proceed from the egg which the female deposits in them. The neuters are six times smaller than the females, and their cells are built nearly in the same proportion. Cells are not only adapted for the reception of neuters, males, and females, but it is remarkable that the cells of the neuters are never intermixed with those of the males or females. A comb is entirely occupied with small cells fitted for the reception of neuter worms. But male and female cells are often found in the same comb. The males and females are of equal length, and, of course, require cells of an equal depth. But the cells of the males are narrower than those of the females, because the bodies of the former are never so thick as those of the latter.

This wonderful assemblage of combs, of the pillars which support them, and of the external envelope, is an edifice which requires several months' labour, and serves the animals one year only. This habitation, so populous in summer, is almost deserted in winter, and abandoned entirely in spring; for, in this last season, not a single wasp is to be found in a nest of the preceding year. It is worthy of remark,



that the first combs of a nest are always accommodated for the reception of the neuter or working wasps. The city, of which the foundation has just been laid, requires a number of workers. The neuter or working wasps are accordingly first produced. A cell is no sooner half completed than an egg of a neuter is deposited in it by the female. Of fourteen or fifteen combs inclosed in a common cover, the last four only are destined for the reception of males and females. Hence it uniformly happens, that, before the males and females are capable of taking flight, every wasp's nest is peopled with several thousand neuters or workers. But the neuters, that are first produced, are likewise the first that perish: for not one of them survives the termination even of a mild winter.

The female wasps are stronger, and support the rigours of winter better than the males or neuters. Before the end of winter, however, several hundred females die, and not above ten or a dozen in each nest survive that season. These few females are destined for the continuation of the species. Each of them becomes the founder of a new republic. When a queen-bee departs from a hive in order to establish a new one, she is always accompanied by several thousand industrious labourers, ready to perform every necessary operation. But the female wasp has not the aid of a single labourer; for all the neuters are dead before the beginning of spring. The female alone lays the foundation of a new republic. She either finds or digs a hole under the earth, builds cells for the reception of her eggs, and feeds the worms which proceed from them. Whenever any of these neuter worms are transformed into flies, they immediately assist their parent in augmenting the number of cells and combs, and in feeding the young worms, which are daily hatching from the eggs. In a word, this female wasp, which in spring was per-

fectly solitary, without any proper habitation, and had every operation to perform, has, in autumn, several thousands of her offspring at her devotion, and is furnished with a magnificent palace, or rather city, to protect her from the injuries of the weather and from external enemies.

With regard to the male wasps, it is uncertain whether any of them survive the winter. But, though not so indolent as the males of the honey-bee, they can be of little assistance to the female; for they never engage in any work of importance, such as constructing cells, or fortifying the external cover of the nest. They are never brought forth till toward the end of August: and their sole occupation seems to be that of keeping the nest clean. They carry out every kind of filth, and the carcasses of such of their companions as happen to die. In performing this operation, two of them often join, and when the load is too heavy, they cut off the head, and transport the dead animal at two different times.

In the beginning of spring, when the female wasp has built her subterraneous habitation, which is soon to be peopled with thousands of flies, she has no occasion for the males; because, in the month of September or October, she had been previously impregnated. The males and females are produced at the same time, and they are nearly equal in number. Like the male honey-bees, the male wasps are destitute of stings, but the females and neuters have stings.



## No. XL.

CONCLUDING CONSIDERATIONS ON THE  
WONDERFUL INGENUITY OF CERTAIN  
INSECTS.

Deum namque ire per omnes  
Terrasque, tractusque maris, cœlumque profundum.

VIRGIL.

For God the whole created mass inspires.

DRYDEN.

THE association and economy of ants, merit no less attention than those of bees and wasps. With wonderful industry and activity they collect materials for the construction of their nest. They unite in numbers, and assist each other in excavating the earth, and in transporting to their habitation bits of straw, small pieces of wood, and other substances of a similar kind, which they employ in lining and supporting their subterraneous galleries. The form of their nest or hill is somewhat conical, and, of course, the water, when it rains, runs easily off, without penetrating their abode. Under this hill there are many galleries or passages which communicate with each other, and resemble the streets of a small city.

Ants not only associate for the purpose of constructing a common habitation, but for cherishing and protecting their offspring. Every person must have often observed, when part of a nest is suddenly exposed, their extreme solicitude for the preservation of their chrysales, or nymphs, which often exceed the size of the animals themselves. With amazing dexterity and quickness the ants transport their nymphs into the subterraneous galleries of the nest,

and place them beyond the reach of any common danger. The courage and fortitude with which they defend their young is no less astonishing. The body of an ant was cut through the middle, and, after suffering this cruel treatment, so strong was its parental affection, with its head, and one half of the body, it carried off eight or ten nymphs. They go to great distances in search of provisions. Their roads, which are often winding and involved, all terminate in the nest.

The wisdom and foresight of ants have been celebrated from the remotest antiquity. It has been asserted and believed, for near three thousand years, that they lay up magazines of provisions for the winter, and that they even cut off the germ of the grain to prevent it from shooting. But the ancients were never famed for accurate researches into the nature and operations of insects. Collections of larvæ were long mistaken for magazines of corn and other food, which it was supposed the ants deposited in granaries for winter consumption. But the truth is, ants are almost wholly carnivorous; they do not feed on corn; they are total strangers to hoarding, and none of their cells are constructed for that purpose. The food which ants appear to relish more than all others, is an exudation from the bodies of several species of aphis, insects which abound on the plants in the vicinity of ant-hills. This species of honey is absorbed with great avidity by the ants, and apparently without the least detriment to the insect that yields it. M. Huber informs us that the liquor is voluntarily given out by the aphis, when solicited so to do by the ant, which, for that purpose, strikes it gently, but repeatedly, with its antennæ, using the same motions as it does when caressing its young. A single aphis is sufficient to supply, in this way, many ants with a plentiful meal.

Most insects become torpid when their temperature approaches the freezing point. Ants present a remarkable exception to this rule; for they are not benumbed till the thermometer has descended five degrees of Fahrenheit *below* the freezing point. They, therefore, have need of a supply of provisions during the greatest part of the winter, although they then require less than in summer. Their principal resource, however, continues still the same, namely, the honey of the aphids. And it is remarkable that the aphid becomes torpid at precisely the same temperature as the ant; a coincidence which tends to confirm the opinion that the natural secretion of which we have been speaking was *intended* for the subsistence of ants.

Ants present us with several striking analogies to bees. In each of them we distinguish three modifications of sex, the *males*, the *females*, and the imperfects, or *labourers*. The latter are, with respect to sex, in the same condition as the working bees; that is, they are females in which the distinctive organs are not developed, and which are, therefore, barren. In each hive of bees, however, there is but one queen permanently; whereas a great number of queens, or female ants, are met with, living in the utmost harmony, in the same nest.

The different species of ants are distinguished from each other by great diversities of manners. This is especially manifested in the construction of their habitations. Some employ merely earth as the material; others fragments of leaves, of bark, or of straw; others nothing but pulverized portions of decayed wood. The *brown ant* exhibits the most perfect specimens. Their nests are formed of parallel, or concentric stories, each four or five lines in height; the partitions being about half a line in thickness, and having their interior perfectly smooth. *Each* of these stories contains chambers of different



sizes, having long galleries of communication. The ceilings of the larger species are supported by small pillars, sometimes by slender walls, at others by arches. The smaller cells, and the larger ones, or halls, with passages of communication, are most skillfully distributed, many of the latter converging towards one larger area, like streets towards a market place. The whole nest frequently contains twenty of these stories, in which the workmanship and arrangement of every part, are calculated to excite our admiration<sup>1</sup>.

Beside the *associating* insects, whose operations I have described, there are several species of bees distinguished by the appellation of *solitary*, because they do not associate to carry on any joint operations. Of this kind is the mason-bee, so called because it builds a habitation composed of sand and mortar. The nests of this bee are fixed to the walls of houses, and, when finished, have the appearance of irregular prominences arising from dirt or clay accidentally thrown against a wall or stone by the feet of horses. These prominences are not so remarkable as to attract attention; but, when the external coat is removed, their structure is discovered to be truly admirable. The interior part consists of an assemblage of different cells, each of which affords a convenient lodgement to a white worm, very similar to those produced by the honey-bee. Here they remain till they have undergone all their metamorphoses. In constructing this nest, which is a work of great labour and dexterity, the female is the sole operator. She receives no assistance from the male. The manner in which the female mason-bees build

<sup>1</sup> For much curious information relative to the manners and habits of ants, see M. Huber's *Recherches sur les Mœurs des Fourmis Indigènes*, Paris 1810, and every able Analysis of this work in the Edinb. Rev. vol. xx, p. 143.

their nests is the most curious branch of their history.

After choosing a part of a wall on which she is resolved to fix a habitation for her future progeny, she goes in quest of proper materials. The nest to be constructed must consist of a species of mortar of which sand is the basis. She knows, like human builders, that every kind of sand is not equally proper for making good mortar; she goes, therefore, to a bed of sand, and selects, grain by grain, the kind which is best to answer her purpose. With her teeth, which are as large and as strong as those of the honey-bee, she examines and brings together several grains. But sand alone will not make mortar; recourse must be had to a cement similar to the slaked lime employed by masons. Our bee is unacquainted with lime, but she possesses an equivalent in her own body. From her mouth she throws out a viscid liquor, with which she moistens the first grain pitched upon; to this grain she cements a second, which she moistens in the same manner, and to the former two she attaches a third, and so on, till she has formed a mass as large as the shot usually employed to kill hares. This mass she carries off in her teeth to the place she had chosen for erecting her nest, and makes it the foundation of the first cell. In this manner she labours incessantly till all the cells are completed, a work which is generally accomplished in five or six days. All the cells are similar, and nearly equal in dimensions. Before they are covered their figure resembles that of a thimble. She never begins to make a second till the first be finished. Each cell is about an inch high, and nearly half an inch in diameter. But the labour of building is not the only one this female bee has to undergo. When a cell has been raised to two-thirds of its height, another occupa-

tion commences. She seems to know the quantity of food that will be necessary to nourish the young that is to proceed from the egg, from its exclusion till it acquires its full growth, and passes into the chrysalis state. The food which is prepared for the support of the young worm consists of the farina or powder of flowers diluted with honey, which forms a kind of pap. Before the cell is entirely finished, the mason-bee collects from the flowers, and deposits in the cell, a large quantity of farina, and afterward disgorges upon it as much honey as dilutes it, and forms it into a kind of paste, or syrup. When this operation is performed, she completes her cell, and, after depositing an egg in it, covers the mouth of it with the same mortar she uses in building her nest. The egg is now inclosed on all sides in a walled habitation hermetically sealed. A small quantity of air, however, gets admission to the worm, otherwise it could not exist. Reaumur discovered that air actually penetrated through this seemingly compact mason-work.

As soon as the first cell is completed, the mason-bee lays the foundation of another. In the same nest she often constructs seven or eight cells, and sometimes only three or four. She places them near each other, but not in any regular order. This industrious animal, after all her cells are constructed, filled with provisions, and sealed, covers the whole with an envelope of the same mortar, which when dry is as hard as a stone. The nest now is commonly of an oblong or roundish figure, and the external cover is composed of coarser sand than that of the cells. As the nests are almost as durable as the walls on which they are placed, they are often, in the following season, occupied and repaired by a stranger bee. Though inclosed with two hard walls, when the fly emerges from the chrysalis state, it first gnaws with its teeth a passage through the



wall that sealed up the mouth of its cell ; afterward, with the same instruments, it pierces the still stronger and more compact cover which invests the whole nest ; at last it escapes into the open air, and, if a female, in a short time, constructs a nest of the same kind with that which the mother had made. To all these facts, Du Hamel, Reaumur, and many other naturalists of credit and reputation, have been repeatedly eyewitnesses.

From the hardness of the materials with which the mason-bee constructs her nest, from the industry and dexterity she employs to protect her progeny from enemies of every kind, we may naturally imagine that the young worms were in perfect safety, and that their castle was impregnable. But, notwithstanding all these favourable precautions, the young of the mason-bee are often devoured by the instinctive dexterity of certain species of four-winged insects, distinguished by the name of ichneumon flies. These flies, when the mason-bee has nearly completed a cell, and filled it with provisions, deposit their own eggs in her cell. After the eggs of the ichneumon flies are hatched, their worms devour not only the provisions laid up by the mason-bee, but even her progeny which she had laboured so hard, and with so much art and ingenuity, to protect. But the mason-bee has an enemy still more formidable. A certain fly employs the same stratagem of insinuating an egg into one of her cells before it is completed. From this egg proceeds a strong and rapacious worm, armed with prodigious fangs. The devastations of this worm are not confined to one cell. He often pierces through each cell in the nest, and successively devours both the mason-worms, and the provisions so anxiously laid up for their support by the mother. This stranger worm is afterward transformed into a beetle, which is enabled to pierce the nest, and to make its escape.

The operations of another species of solitary bees, called wood-piercers, likewise merit attention. These bees are larger than the queens of the honey-bee. Their bodies are smooth, except the sides, which are covered with hair. In the spring, they frequent gardens, and search for rotten, or at least dead wood, in order to make a habitation for their young. When a female of this species (for she receives no assistance from the male) has selected a piece of wood or a decayed tree, she commences her labour by making a hole in it, which is generally directed toward the axis of the tree. When she has advanced about half an inch she alters the direction of the hole, and conducts it nearly parallel to the axis of the wood. The size of her body requires that this hole should have a considerable diameter. It is often so large as to admit the finger of a man, and it sometimes extends from twelve to fifteen inches in length. If the thickness of the wood permits, she makes three or four of these long holes in its interior part. Reaumur found three of these parallel holes in an old espalier post. Their diameters exceeded half an inch. This labour, for a single bee, is prodigious; but, in executing it, she consumes weeks, and even months.

Around the foot of a post or piece of wood where one of these bees is working, little heaps of timber-dust are always found lying on the ground. These heaps daily increase in magnitude, and the particles of dust are as large as those produced by a hand-saw. The two teeth with which the animal is provided are the only instruments she employs in making such considerable perforations. Each tooth consists of a solid piece of shell, which in shape resembles an auger. It is convex above, concave below; and terminates in a sharp but strong point.

These long holes are designed for lodgings to the worms that *are to proceed* from the eggs which the



bee is soon to deposit in them. But after the holes are finished, her labour is by no means at an end. The eggs must not be mingled, or piled above each other. Every separate worm must have a distinct apartment, without any communication with the others. Each long hole or tube, accordingly, is only the outer walls of a house which is to consist of many chambers raised one above another. A hole of about twelve inches in length she divides into ten or twelve separate apartments, each of which is about an inch high. The roof of the lowest room is the floor of the second, and so on to the uppermost. Each floor is about the thickness of a French crown. The floors or divisions are composed of particles of wood cemented together by a glutinous substance from the animal's mouth. In making a floor, she commences with gluing an annular plate of wood-dust round the internal circumference of the cavity. To this plate she attaches a second, to the second a third, and to the third a fourth, till the whole floor is completed. The undermost cell requires only a roof, and this roof is a floor to the second, &c.

I have hitherto described the wonderful assiduity of this animal in constructing her cells. But this operation, though great, and seemingly superior to the powers of a creature so small, is not her only labour. Before roofing in the first cell, she fills it with a paste or pap, composed of the farina of flowers moistened with honey. The quantity of paste is equal to the dimensions of the cell; and into this paste, which is to nourish the future worm, she deposits an egg. Immediately after this operation, she begins to form a roof, which not only incloses the first cell, but serves as a floor to the second. The second cell she likewise fills with paste, deposits an egg, and then covers the whole with another roof. In this manner she proceeds, till the whole tube is divided into separate cells, when the busi-

ness of this laborious bee is finished, and she takes no more charge of her future progeny. The attention and solicitude bestowed by many other animals in rearing their young, are exerted after birth; but in the wood-piercing bee, as well as in many other insects, this instinctive attachment is reversed. All her cares and labours are exerted before she either sees her offspring, or knows that they are to exist. But, after the description that has been given of her amazing operations, she will not be considered as an unnatural mother. With astonishing industry and perseverance, she not only furnishes her young with safe and convenient lodgings, but lays up for them stores of provisions sufficient to support them till their final metamorphosis into flies, when the new females perform the same almost incredible operations for the protection and sustenance of their own offspring. When the young worm is hatched, it has scarcely sufficient space to turn itself in the cell, which is almost entirely filled with the pappy substance formerly mentioned. But, as this substance is gradually devoured by the worm, the space in the cell necessarily enlarges in proportion to the growth and magnitude of the animal.

In a range of cells, the worms are of different ages, and, of course, of different sizes. Those in the lower cells are older than those in the superior; because, after the bee has filled with paste and inclosed its first cell, a considerable time is requisite to collect provisions, and to form partitions for every successive and superior cell. The former, therefore, must be transformed into nymphs and flies before the latter. These circumstances are apparently foreseen by the common mother; for, if the undermost worm, which is oldest, and soonest transformed, were to force its way upward, which it could easily do, it would not only disturb, but infallibly destroy all those lodged in the superior cells.

But nature has wisely prevented this devastation; for the head of the nymph, and consequently of the fly, is always placed in a downward direction. Its first instinctive movements must, therefore, be in the same direction. That the young flies may escape from their respective cells, the mother digs a hole at the bottom of the long tube, which makes a communication with the undermost cell and the open air. Sometimes a similar passage is made near the middle of the tube. By this contrivance, as all the flies instinctively endeavour to cut their way downward, they find an easy and convenient passage; for they have only to pierce the floor of their cells, which they readily perform with their teeth.

Another small species of solitary bees dig holes in the earth to make a convenient habitation for their young. Their nests are composed of cylindrical cells fixed to one another, and each of them, in figure, resembles a thimble. Their bottom, of course, is convex and rounded. The bottom of the second is inserted into the entry of the first; and the entry of the second receives the bottom of the third. Sometimes only two of these cells are joined together; and, at other times, we find three or four, which form a kind of cylinder. This cylinder is composed of alternate bands of two different colours: those of the narrowest, at the juncture of two cells, are white, and those of the broadest are of a reddish brown. The cells consist of a number of fine membranes, formed of a glutinous and transparent substance from the animal's mouth. The bee fills each cell with the farina of flowers diluted with honey, and in this paste she deposits an egg. She then covers the cell, by gluing to its mouth a fine cellular substance taken from the leaves of some plant; and in this manner she proceeds till her cylindrical nest is completed. The worms which are hatched from

the eggs feed upon the paste, so carefully laid up for them by the mother, till they are transformed into flies similar to their parents.

Among wasps, as well as bees, there are solitary species, which carry on no joint operations. These solitary wasps are not less ingenious in constructing proper habitations for their young, nor less provident in laying up for them a store of nourishment sufficient to support them till they are transformed into flies, or have become perfect animals.

I shall conclude this paper with observing, that some of the ancient philosophers, and, in particular, Pythagoras and Plato, were so struck by the wonderful ingenuity displayed in the operation of bees, that they thought them endued, not merely with instinct, but with something of celestial intellect. To this idea Virgil thus alludes :

His quidam signis, atque hæc exempla secuti,  
Esse apibus partem divinæ mentis, et haustus  
Æthereos dixerunt.

Induced by such examples, some have taught  
That bees have portions of ethereal thought;  
Endued with particles of heav'nly fires.

DRYDEN.



## No. XLI.

## SUMMER REFLECTIONS.

From brightening fields of ether fair disclosed,  
 Child of the Sun, refulgent Summer comes,  
 In pride of youth, and felt through Nature's depth :  
 He comes attended by the sultry Hours,  
 And ever-fanning Breezes, on his way ;  
 While, from his ardent look, the turning Spring  
 Averts her blushful face ; and earth and skies  
 All smiling, to his hot dominion leaves.      THOMSON.

Now jocund Summer, with her honied breath,  
 Sweetening the golden grain and blithsome gale,  
     Displays her sun-burnt face,  
     Beneath her hat of straw.      HEADLEY.

IN the month of May the Spring glows with 'all the mixtures of colorific radiance,' and before the expiration of June that season commences when opening beauty and increasing variety are succeeded by the more uniform scenes of maturity and perfection.

The Summer season, which commences on the twenty-first of June, is so distinguished by a uniformity of character, that, as I have observed before, the great poet of the Seasons has comprised the whole of his description within the limits of a single day. To give importance, moreover, to a season, in other respects so unproductive of subject, his muse has spread her flight to the torrid zone, and enriched her landscape with foreign beauties and exotic wonders.

Nature, in our temperate regions, appears in this season to have nearly finished her annual work ; and she begins to lose something of her variety. Nothing, indeed, can be more beautiful than the ver-

ture of the orchards and woods, but the shades of hue which they exhibit are no longer so agreeable. The meadows begin to whiten, and the flowers that adorn them are mowed down. The corn gradually assumes a yellow hue, and the colours that decorate the rural scene are no longer so numerous. How lately did the glowing beauty and variety of these, with the notes, as various, of a multitude of birds, display at once all the charms of novelty, and inspire inexpressible delight!

It is in the novelty of objects, indeed, in their appearing at least to be new and uncommon, that the more exquisite enjoyment of them consists. Novelty excites a pleasure in the imagination, because it strikes the soul with an agreeable surprise, gratifies its curiosity, and gives it an idea of which it was not possessed before. It contributes, therefore, to vary human life: it tends to divert and refresh the mind, and to take off that satiety of which we are apt to complain in the entertainments to which we are constantly accustomed; it is that which gives its charm to variety, where the mind is every instant called off to something new, and the attention not suffered to dwell too long, and waste itself, on any particular object. Novelty, moreover, improves whatever is beautiful and pleasing, and makes it afford to the mind a double entertainment.

Hence we may deduce the reason why the groves, and fields, and meadows, which, at any season of the year are delightful to the view, are never more so than in the opening of Spring, when they are all new and fresh, with their first gloss upon them, and not yet too familiar to the eye. But in Summer, in proportion as we advance toward Autumn, these pleasing effects insensibly decrease; the song of the nightingale is no longer heard; and that favourite enjoyment of the country, a walk through fields of



verdure, becomes inconvenient and unpleasing, on account of the great heat which sometimes prevails.

Yet Summer has still inexpressible charms, and exhibits proofs every day of the unbounded goodness of the great Creator. It is that season of felicity in which he dispenses his blessings more abundantly to every living creature. Nature, after having reanimated and enlivened us by all the pleasures of Spring, is incessantly employed, during Summer, to provide those enjoyments which are most agreeable to the senses, to facilitate the means of subsistence, and to excite in our breasts the correspondent sentiments of gratitude and love.

What can be more delightful than to view the waving fields of corn just bending to the sickle! what theme can so powerfully call forth the song of praise to the GOD of HARVESTS! How innocent, how grateful, the employment of the reaper!

Waked by the gentle gleamings of the morn,  
Soon clad, the reaper, provident of want,  
Hies cheerful-hearted to the ripened field;  
Nor hastes alone; attendant by his side  
His faithful wife, sole partner of his cares,  
Bears on her breast the sleeping babe; behind  
With steps unequal trips her infant train:  
Thrice happy pair, in love and labour join'd!—

All day they ply their task; with mutual chat  
Beguiling each the sultry, tedious hours.  
Around them falls in rows the severed corn,  
Or the shocks rise in regular array.

But when high noon invites to short repast,  
Beneath the shade of sheltering thorn they sit,  
Divide the simple meal, and drain the cask:  
The swinging cradle lulls the whim'ring babe  
Meantime; while growling round, if at the tread  
Of hasty passenger alarmed, as of their store  
Protective, stalks the cur with bristling back,  
To guard the scanty scrip and russet frock<sup>1</sup>.

<sup>1</sup> White's Selborne, vol. ii, p. 343.

Agreeably to the method I have adopted, of enriching these discussions with poetical description, I shall here present my readers with the most striking parts of a summer's day, which, not to multiply quotations, I shall select only from the poet of the seasons.

## MORNING.

When now no more th' alternate *Twins* are fired,  
 And *Cancer* reddens with the solar blaze,  
 Short is the doubtful empire of the Night,  
 And soon, observant of approaching Day,  
 The meek-eyed Morn appears, mother of dews,  
 At first faint-gleaming in the dappled east:  
 And, from before the lustre of her face,  
 White break the clouds away. With quickened step,  
 Brown Night retires: Young Day pours in apace,  
 And opens all the lawny prospect wide.  
 The dripping rock, the mountain's misty top,  
 Swell on the sight, and brighten with the dawn.  
 Blue, thro' the dusk, the smoking currents shine;  
 And from the bladed field the fearful hare  
 Limp, awkward: while along the forest glade  
 The wild deer trip, and often turning gaze  
 At early passenger. Music awakes  
 The native voice of undissembled joy;  
 And thick around the woodland hymns arise.

\* \* \* \*

But yonder comes the powerful King of Day,  
 Rejoicing in the east. The lessening cloud,  
 The kindling azure, and the mountain brow  
 Illumed with fluid gold, his near approach  
 Bewoken glad. Lo! now, apparent all,  
 Aslant the dew-bright earth, and coloured air,  
 He looks in boundless majesty abroad;  
 And sheds the shining day, that burnished plays  
 On rocks and hills, and towers, and wandering streams,  
 High gleaming from afar.

## FORENOON.

Now, flaming up the heavens, the potent Sun  
 Melts into limpid air the high-raised clouds,  
 And morning fogs, that hovered round the hills  
 In party-coloured bands; till wide unveiled

The face of Nature shines, from where earth seems,  
Far stretched around, to meet the bending sphere.

## NOON.

'Tis raging noon ; and, vertical, the Sun  
Darts on the head direct his forceful rays.  
O'er heaven and earth, far as the ranging eye  
Can sweep, a dazzling deluge reigns ; and all,  
From pole to pole, is undistinguished blaze.  
In vain the sight, dejected to the ground,  
Stoops for relief ; thence hot ascending steams  
And keen reflection pain. Deep to the root  
Of vegetation parched, the cleaving fields  
And slippery lawn an arid hue disclose,  
Blast Fancy's blooms, and wither e'en the soul.  
Echo no more returns the cheerful sound  
Of sharpening sithe ; the mower sinking heaps  
O'er him the humid hay, with flowers perfumed ;  
And scarce a chirping grasshopper is heard  
Thro' the dumb mead. Distressful Nature pants.  
The very streams look languid from afar ;  
Or, thro' th' unsheltered glade, impatient, seem  
To hurl into the covert of the grove.

## AFTERNOON.

The Sun has lost his rage ! His downward orb  
Shoots nothing now but animating warmth,  
And vital lustre ; that, with various ray,  
Lights up the clouds, those beauteous robes of heaven,  
Incessant rolled into romantic shapes,  
The dream of waking Fancy ! Broad below,  
Covered with ripening fruits, and swelling fast  
Into the perfect year, the pregnant earth  
And all her tribes rejoice. Now the soft hour  
Of walking comes ; for him who lonely loves  
To seek the distant hills, and there converse  
With Nature.

## EVENING.

Low walks the Sun, and broadens by degrees,  
Just o'er the verge of day. The shifting clouds  
Assembled gay, a richly-gorgeous train,  
In all their pomp attend his setting throne.  
Air, earth, and ocean smile immense. And now,  
As if his weary chariot sought the bowers  
Of Amphitrite and her tending nymphs

(So Grecian fable sung) he dips his orb ;  
Now half immersed ; and now a golden curve  
Gives one bright glance, then total disappears.

\* \* \* \* \*

Confessed from yonder slow-extinguished clouds,  
All ether softening, sober Evening takes  
Her wonted station in the middle air,  
A thousand *shadows* at her beck. First *this*  
She sends on earth ; then *that* of deeper die  
Steals soft behind ; and then a *deeper* still,  
In circle following circle, gathers round,  
To close the face of things. A fresher gale  
Begins to wave the wood, and stir the stream,  
Sweeping with shadowy gust the fields of corn ;  
While the quail clamours for his running mate.  
Wide o'er the thistly lawn, as swells the breeze,  
A whitening shower of vegetable down  
Amusive floats. The kind impartial care  
Of Nature nought disdains : thoughtful to feed  
Her lowest sons, and clothe the coming year,  
From field to field the feathered seed she wings<sup>1</sup>.

#### NIGHT.

Among the crooked lanes, on every hedge,  
The glowworm lights his gem ; and, thro' the dark  
A moving radiance twinkles. Evening yields  
The world to Night ; not in her winter robe  
Of massy Stygian woof, but loose arrayed  
In mantle dun. A faint erroneous ray,  
Glanced from th' imperfect surfaces of things,

<sup>1</sup> The late lamented KIRKE WHITE has pencilled the  
'Summer's Eve' with great truth and delicacy :—

Down the sultry arc of day  
The burning wheels have urged their way,  
And Eve, along the western skies,  
Sheds her intermingling dyes.  
Down the deep, the miry lane,  
Creeking comes the empty wain,  
And driver on the shaft-horse sits,  
Whistling now and then by fits ;  
And oft, with his accustomed call,  
Urging on the sluggish Ball.  
The barn is still, the master's gone,  
And thrasher puts his jacket on ;

Flings half an image on the straining eye ;  
 While wavering woods, and villages, and streams,  
 And rocks, and mountain-tops, that long retained  
 Th' ascending gleam, are all one swimming scene,  
 Uncertain if beheld. Sudden to heaven  
 Thence weary vision turns ; where, leading soft  
 The silent hours of love, with purest ray  
 Sweet Venus shines ; and from her genial rise,  
 When daylight sickens till it springs afresh  
 Unrivalled reigns the fairest lamp of night. <sup>1</sup>

These principal parts of a summer's day, but more particularly morning, evening, and night, have been the favourite theme of poets, from the most remote antiquity. Each has something picturesque and beautiful that affects every sense with unspeakable pleasure ; particularly the sight, which is the most perfect and most delightful of all our senses : which fills the mind with the greatest variety of ideas ; converses with its objects at the remotest distance : and continues the longest in action without being

While Dick upon the ladder tall  
 Nails the dead kite to the wall.  
 Here comes shepherd Jack at last,  
 He has penned the sheep-cote fast,  
 For 'twas but two nights before  
 A lamb was eaten on the moor ;  
 His empty wallet Rover carries,  
 Nor for Jack, when near home, tarries ;  
 With lolling tongue he runs to try  
 If the horse-trough is not dry.  
 The milk is settled in the pans,  
 And supper messes in the cans ;  
 In the hovel, carts are wheeled,  
 And both the colts are drove a-field ;  
 The horses all are bedded up,  
 And the ewe is with the tup.  
 The snare for Mister Fox is set,  
 The leaven laid, the thatching wet ;  
 And Bess has slinked away to talk  
 With Roger in the holly walk.

<sup>1</sup> See *Reflections on a Moonlight Scene*, in No. xxii.



tired or satiated with its proper enjoyments. Beside the glowing colours of the flowers, and the still enlivening verdure of the woods, the eye beholds an innumerable quantity of fruits, which, by virtue of the secret laws of Nature, grow in our fields and gardens, and which, after thus delighting the sense of vision, may be gathered and preserved, to contribute to our subsistence. The flowers present to our senses the most agreeable diversity: we not only admire the richness of their attire, but the fecundity of Nature in the numberless species of them. What variety too, what beauty in every plant, from the lowly moss to the towering oak! If we wander from flower to flower, the eye is still unsatiated with the view. If we ascend the highest mountains, pierce into the midnight depth of the groves, or descend into the spacious vale, we discover new beauties spread around in wonderful profusion. Of the infinity of objects that strike the eye, each is different from the other; but each has in itself sufficient beauty to attract and to fix our attention: yonder a distant prospect, terminated by a beautiful horizon; here the rich and variegated landscape: there herds of cattle and flocks of sheep; here flowers and plants, 'beyond the power of botanist to number up their tribes.' If we lift up our eyes, we behold the blue concave, refulgent and serene. Adverting to the landscape around, the eye, just dazzled by celestial radiance, is cheered again by the bright verdure of the fields.

Nor is the sense of *hearing* unaffected by the universal charm; it is still enraptured by the music of the woods. The murmurings too of the brook, or of the silver waves which the river rolls in its majestic course, are pleasing to the ear. The *taste* is gratified by the early fruits that ripen in this season, and which, exclusive of their pleasing flavour, have the most cooling salutary virtues. The sense of



*smelling* is delighted with the fragrance diffused from all around. In a word, a thousand objects exercise our senses, and excite our sensibility. The flocks and herds, nourished by the lavish hand of Nature, crop the wholesome herb, to afford us nutriment and clothing. Kindly rains bedew the soil with plenty, and open new sources of thanksgiving. The tufted trees and bowery thickets refresh us with their welcome shade. Whatever we *see*, and whatever we *hear*; whatever can delight the *taste*, or the sense of *smelling*, augments the number of our pleasures, and contributes to felicity.

But a view of the creation at this season is still more enchanting, when considered as a source of pleasure to the understanding, which discovers what the senses cannot attain: it contemplates beauty, harmony, variety, and pleasure unperceived before. In every object of Nature, it beholds the great Creator of all, the Source of life and beauty, the Author of every good. Inspired by scenes, in which infinite wisdom and unbounded goodness are incessantly conspicuous, with what rapture will the Contemplative Philosopher, the genuine son of Nature, exalt his voice to heaven, in the glowing language of gratitude and adoration: "Yes! (he may exclaim) Thou Best of Beings! how unutterable is thy goodness! I behold thee in all thy wondrous works. The radiant orb of day, and, in the night, the silver moon, and all the stars, the life-infusing suns of other worlds, proclaim the Great Omnipotent. In the balsamic fragrance of the flowers I behold that incense rise, which, in mingled clouds, they roll soft to thee, 'whose sun exalts, whose breath perfumes, and whose pencil paints them.' In the delicious fruits I taste, I perceive thy unconfined and unexhausted bounty. Whatever pleasures I enjoy by the kind communication of my senses, shall recall me to thee, as the object of devout and

fervent aspiration; and thou, most adorable Being, who gavest me these sensations, wilt thus exalt and ennoble them. While I am still intent in contemplating these material beauties, I soar insensibly to the most sublime objects, to the centre of all perfection. Yes! Thou Good Supreme, thee I invoke, thee alone adore! To thee this lonely spot, this pleasing solitude, these rural thoughts are sacred, while thus I meditate on thy works, and contemplate the beauties which all resolve in thee, thou source and principle of beauty and perfection!"

Such are the natural effusions of the Contemplative Philosopher, when his eye wanders over the beauties of the Summer. And what pleasure and serenity do such meditations inspire! Can any terrestrial enjoyments be placed in competition with the manly sources of delight which they afford? Can the wise and virtuous be ever satiated with such themes? No: were they to witness the revolution of a thousand Summers, they would still discover new objects of admiration, and new subjects of praise and adoration.

For me, when I forget the darling theme,  
Whether the blossom blows, the Summer ray  
Russets the plain, inspiring Autumn gleams,  
Or Winter rises in the blackening east,  
Be my tongue mute, may Fancy paint no more,  
And, dead to joy, forget my heart to beat!

THOMSON.

## No. XLII.

## A MORNING WALK.

Look, love, what envious streaks  
Do lace the severing clouds in yonder east:  
Night's candles are put out: and jocund Day  
Stands tiptoe on the misty mountain's top.

SHAKESPEARE.

Sweet is the breath of Morn, her rising sweet,  
With charm of earliest birds; pleasant the Sun,  
When first on this delightful land he spreads  
His orient beams on herb, tree, fruit, and flower,  
Glistening with dew.

MILTON.

WHAT a magnificent phenomenon is every day exhibited in the rising of the sun! yet how common is the observation, that indolence and the love of sleep prevent a great part of mankind from contemplating this beauteous wonder of the creation! What numbers are there, in high life especially, who prefer a few more hours of sleep to all the pleasures of a morning walk!

This circumstance has been ridiculed with great propriety by one of my predecessors: 'This unaccountable disposition in mankind, to continue awake in the night, and sleep in the sunshine, has made me inquire, whether the same change has happened to any other animals? For this reason, I desired a friend of mine in the country to let me know, whether the lark rises as early as it did formerly, and whether the cock begins to crow at his usual hour? My friend has answered me, That his poultry are as regular as ever, and that all the birds and the beasts of his neighbourhood keep the same hours that they have observed in the memory of man; and



the same which, in all probability, they have kept for these five thousand years.' The same excellent author continues, in a more serious strain, 'Who would not wonder at this perverted relish of those who are reckoned the most polite part of mankind, that prefer coal and candles to the Sun, and exchange so many cheerful morning hours, for the pleasures of midnight revels and debauches? If a man were only to consult his health, he would choose to live his whole time, if possible, in daylight, and to retire out of the world into silence and sleep, while the raw damps and unwholesome vapours fly abroad, without a sun to disperse, moderate, or control them. For my own part, I value an hour in the morning as much as common libertines do an hour at midnight. When I find myself awakened into being, and perceive my life renewed within me, and, at the same time, see the whole face of Nature recovered out of the dark uncomfortable state in which it lay for several hours, my heart overflows with such secret sentiments of joy and gratitude, as are a kind of implicit praise to the great Author of Nature. The mind, in these early seasons of the day, is so refreshed in all its faculties, and borne up with such new supplies of animal spirits, that she finds herself in a state of youth, especially when she is entertained with the breath of flowers, the melody of birds, the dews that hang upon the plants, and all those other sweets of Nature that are peculiar to the morning.—But it is impossible for a man to have this relish of being, this exquisite taste of life, who does not come into the world before it is in all its noise and hurry; who loses the rising of the sun, the still hour of the day, and immediately upon his first getting up plunges himself into the ordinary cares or follies of the world.'

And such are the sentiments of the poet of the

Seasons, whose soul was so capable of enjoying, and his genius of describing, the pleasures of the Morning:

Falsely luxurious, will not man awake :  
 And, springing from the bed of sloth, enjoy  
 The cool, the fragrant, and the silent hour,  
 To meditation due and sacred song ?  
 For is there aught in sleep can charm the wise ?  
 To lie in dead oblivion, losing half  
 The fleeting moments of too short a life ;  
 Total extinction of th' enlightened soul !  
 Or else to feverish vanity alive,  
 Wildered, and tossing through distempered dreams ?  
 Who would in such a gloomy state remain  
 Longer than Nature craves ? when every muse  
 And every blooming pleasure wait without,  
 To bless the wildly-devious morning walk ? <sup>1</sup>

But it is not indolence and the love of sleep only that give rise to these observations. Beauty ceases to charm, and magnificence to strike, when the object, however perfect it may be, is become familiar to a mind, unaccustomed to reflect on the order and harmony of the creation, and on those wonderful relations between all the objects of it, which naturally

<sup>1</sup> Herrick has given us some most pleasing lines on early rising, which we willingly address to every female who sacrifices her health to indolence and fashion.

Get up, get up for shame ; the blooming morn  
 Upon her wings presents the God unshorn :  
 See how Aurora throws her fair  
 Fresh-quilted colours through the air .  
 Get up, sweet slug-a-bed, and see  
 The dew bespangling herb and tree :  
 Each flow'r has wept, and bowed toward the east,  
 Above an hour since ; yet you not drest ;  
 Nay, not so much as out of bed ;  
*When all the birds have matins said,*  
 And sung their thankful hymns : 'tis sin,  
 Nay, profanation to keep in.

\* \* \* \*



lead the devout man to the contemplation of a First Cause, the Life, and Soul, and Energy of All. Hence we observe a kind of culpable inattention and indifference, even in those who are most habituated to rural scenes, and who, consequently, must enjoy the most frequent opportunities of admiring and contemplating the works of Nature. Satisfied, for instance, that the sun enlightens the world, and dispenses the most essential benefits to mankind, they have no solicitude, however, to explore the cause of these wonderful effects. They view, every day, the most glorious object in Nature, without one emotion of grateful pleasure, without one idea or reflection.

In *Paradise Lost*, when Adam awakes Eve in the morning, he reminds her of the sweet pleasures she is losing :

Awake,

My fairest, my espoused, my lately found,  
 Heaven's last best gift, my ever new delight,  
 Awake ; the morning shines, and the fresh field  
 Calls us ; we lose the prime, to mark how spring  
 The tender plants, how blows the citron grove,  
 What drops the myrrh, and what the balmy reed,  
 How Nature paints her colours, how the bee  
 Sits on the bloom extracting liquid sweet.<sup>1</sup>

Another poet beautifully observes :

Rise before the sun,

Then make a breakfast of the morning dew  
 Served up by Nature on some grassy hill ;  
 You'll find it nectar.

Those who are constrained to live in large cities,

<sup>1</sup> Milton, in these inexpressibly charming lines, had his eye, no doubt, on a passage in the Song of Solomon : ‘ *Come, my beloved, let us go forth into the field : let us lodge in the villages : let us get up early to the vineyards : let us see if the vine flourish, whether the tender grape appear, and the pomegranates bud forth.*’

and occasionally resort to the country, ought not to need such an invitation:—

The meanest floweret of the vale,  
The simplest note that swells the gale,  
The common sun, the air, the skies,  
To *such* are opening Paradise.

It is certain, that we no where meet with a more glorious or more pleasing show of Nature, than what appears in the heavens at the rising of the sun. The richest decorations, the most variegated and the most gorgeous scenery, that human fancy can imagine, must vanish into nothing, when compared with a spectacle in which radiance and beauty are so pre-eminent. The first aspect of the morning is pale and white, or gray. Hence Milton styles her *Leucothea*, which, in the Greek language, signifies the White Goddess:

To resalute the world with sacred light  
*Leucothea* waked, and with fresh dews embalmed  
The earth.

*Leucothea*, whom the Romans called *Matuta*, is the harbinger of *Aurora*; and the horizon, with the nearer approach of the sunbeams, now assumes a roseate hue. Thus *Lucretius*:—

Roseam *Matuta* per oras  
*Ætheris Auroram* desert, et lumina pandit.  
O'er all the skies *Matuta* spreads her light,  
And brings the morn in roseate colours bright.

And thus *Homer* gives rosy fingers to the Morn<sup>1</sup>, and *Milton* rosy steps<sup>2</sup> and a rosy hand<sup>3</sup>.

<sup>1</sup> Now did the rosy-fingered Morn arise,  
And shed her sacred light along the skies.

<sup>2</sup> Now Morn her rosy steps in th' eastern clime  
Advancing, sowed the earth with orient pearl.

<sup>3</sup> —Morn.

Waked by the circling Hours, with rosy hand,  
Unbarred the gates of light.

The Morning, in fine, displays to the world a new and magnificent creation. The shades of night had concealed the view and enjoyment of earth and skies. But now the light returns, and we behold all Nature renewed in youth and beauty. We are reminded of Milton's fine description of the creation, when God first commanded the earth to 'put forth the verdant grass:'

He scarce had said, when the bare earth, till then  
Desert and bare, unsightly, unadorned,  
Brought forth the tender grass, whose verdure clad  
Her universal face with pleasant green;  
Then herbs of every leaf, that sudden flowered,  
Opening their various colours, and made gay  
Her bosom smelling sweet.—  
—With high woods the hills were crowned,  
With tusks the valleys, and each fountain side  
With borders 'long the rivers; that earth now  
Seemed like to heaven, a seat where gods might dwell,  
Or wander with delight, and love to haunt  
Her sacred shades.

Nor is this poetic fiction: the morning landscape is indeed exquisitely beautiful. We behold the mountains crowned, as if by the instantaneous effect of enchantment, with majestic woods; the spreading lawns covered with herds and flocks; the fields ripening into harvest; and the meadows enamelled with flowers, and watered by meandering streams. The whole horizon looks gay: the scattered clouds assume a vivid variety of hues; the lighter vapours are converted into gold: and every plant and every flower sparkles with orient pearl. In proportion as the day approaches, the spectacle is still more beautiful. By soft progressions of light, Nature at length appears in her utmost perfection. The sun is rising. A first ray escaped from the mountain's top, that still conceals the radiant orb from the sight, darts rapidly from one end of the horizon to the other. Successive rays strengthen the first. The



face of the sun is disengaged by degrees, till it looks, at last, in boundless majesty abroad ! All Nature rejoices in a delightful renovation of life and vigour. The feathered tribes salute the bright source of day with their melodious notes. Every living creature is in action, and is sensible to new returns of pleasure and new capacities of enjoyment.

Mallet has amplified this pleasing subject with the most beautiful and picturesque imagery :

And now pale glimmering on the verge of heaven,  
From east to north in doubtful twilight seen,  
A whitening lustre shoots its tender beam ;  
While shade and silence yet involve the ball.  
Now sacred Morn, ascending, smiles serene  
A dewy radiance, brightening o'er the world.  
Gay daughter of the Air, for ever young,  
For ever pleasing ! Lo, she onward comes,  
In fluid gold and azure loose arrayed,  
Sun-tinctured, changeful hues. At her approach,  
The western gray of yonder breaking clouds  
Slow reddens into flame : the rising mists,  
From off the mountain's brow, roll blue away  
In curling spires, and open all his woods,  
High-waving in the sky : th' uncoloured stream,  
Beneath her glowing ray, translucent shines.  
Glad Nature feels her thro' her boundless realms  
Of life and sense ; and calls forth all her sweets,  
Fragrance and song. From each unfolding flower  
Transpires the balm of life, that Zephyr wafts,  
Delicious, on his rosy wing : each bird,  
Or high in air, or secret in the shade,  
Rejoicing, warbles wild his matin-hymn.  
While beasts of chase, by secret instinct moved,  
Scud o'er the lawns, and, plunging into night,  
In brake, or cavern, slumber out the day.

Invited by the cheerful Morn abroad,  
See, from his humble roof, the good man comes  
To taste her freshness, and improve her rise  
In holy musing. Rapture in his eye,  
And kneeling wonder, speaks his silent soul,  
With gratitude o'erflowing, and with praise !

Now Industry is up. The village pours  
Her useful sons abroad to various toil :

# A Morning Walk.

CLII.

The labourer here, with every instrument  
Of future plenty armed; and there the swain,  
A rural king amid his subject-flocks,  
Whose bleatings wake the vocal hills afar.  
The traveller, too, pursues his early road,  
Among the dews of Morn. Aurora calls:  
And all the living landscape moves around.

But see, the flushed horizon flames intense  
With vivid red, in rich profusion streamed  
O'er heaven's pure arch. At once the clouds assume  
Their gayest liveries; these with silvery beams  
Fringed lovely; splendid those in liquid gold:  
And speak their sovereign's state. He comes, behold!  
Fountain of light and colour, warmth and life!  
The king of glory! Round his head divine,  
Diffusive showers of radiance circling flow,  
As o'er the Indian wave up-rising fair  
He looks abroad on Nature, and invests,  
Where'er his universal eye surveys,  
Her ample bosom, earth, air, sea, and sky,  
In one bright robe, with heavenly tinctures gay.

The limits of this paper will not permit me to  
make any reflections on two beautiful phenomena  
of a morning prospect, which have afforded the  
poets the happiest subjects of description: I mean  
*the Dews* and *the Sun*. Of the first I have already  
amply treated in a former paper; and the latter shall  
be the subject of a future one. At present, I shall  
be content to imagine the Contemplative Philoso-  
pher in his morning walk, enraptured with the  
beautiful face of Nature, and thus pouring forth the  
devout effusions of his heart: 'Adorable Being! In  
the glories of the morning I behold thy infinite wis-  
dom and power. With the soaring lark, whose  
sweet song proclaims the approach of day, I aspire  
to thee, O God, the Father of the Creation. The  
cheerfulness and joy that inspires all Nature, and  
this universal renovation of life and beauty, invite  
me also to raise my heart to thee, with the most  
lively transports of gratitude and joy. At this in-  
stant, that the sun darts its earliest rays upon the



earth, what millions of thy creatures are adoring and praising thee ! How then can I be insensible and silent at this view of universal beauty and universal goodness ? From thee springs the splendour of the morning, from thee, the great fountain of light and life. Thou alone hast spread the horizon with these beauteous tints, and given pervading power and energy to that sun. The verdant earth, the smiling landscape around, is decorated by thy hand. The grateful emotions which the glorious scene inspires spring too from thee. Thou hast endowed me with understanding, with that celestial faculty, which thus enables me to discover thee in thy wondrous works. Continue, Best of Beings, to protect and guide me. Let me not be content with these morning aspirations. Beautiful as this solitude is, and charming as these reflections are, let me now return to social life and to active goodness. Ever grateful to thee, and kind to my fellow-creatures, may a life of uniform piety and virtue be accepted by thee as the noblest hymn of praise and adoration.

---

Dr. Beattie's 'Melodies of Morning,' given in his 'Minstrel,' are too appropriate and elegant, not to deserve a place in this paper :

But who the melodies of morn can tell ?  
 The wild brook babbling down the mountain side ;  
 The lowing herd ; the sheepfold's simple bell ;  
 The pipe of early shepherd dim descried  
 In the lone valley ; echoing far and wide  
 The clamorous horn along the cliffs above ;  
 The hollow murmur of the ocean tide ;  
 The hum of bees, and linnet's lay of love,  
 And the full choir that wakes the universal grove.

The cottage-curs at early pilgrim bark ;  
 Crowned with her pail the tripping milkmaid sings ;  
 The whistling ploughman stalks afield ; and hark !  
 Down the rough slope the ponderous waggon rings ;

Through rustling corn the hare astonished springs,  
 Slow tolls the village-clock the drowsy hour;  
 The partridge bursts away on whirring wings;  
 Deep mourns the turtle in sequestered bow'r,  
 And shrill lark carols clear from her aërial tow'r.

## No. XLIII.

## ON THE SUN.

Alme Sol, curru nitido diem qui  
 Promis et celas, aliusque et idem  
 Nasceris——

HORACE.

Fair Sun, who with unchanging beam  
 Rising another and the same,  
 Dost from thy beamy car unfold  
 The glorious day,  
 Or hide it in thy setting ray——

FRANCIS.

Great source of day! best image here below  
 Of thy Creator, ever pouring wide,  
 From world to world, the vital ocean round,  
 On Nature write with every beam His praise.

THOMSON.

THE Sun has been justly styled the soul of the universe, as it not only produces all the necessities of life, but has a particular influence in cheering the mind of man. He can never be satiated then, one would think, with the glorious scenes which the eye discovers, when this radiant orb sheds its lustre abroad; nor can imagination ever cease to contemplate, with pleasure, its wonderful use and essential importance in the creation.

In my preceding paper, I considered the rising of the sun as forming one of the most beautiful appearances in a morning prospect. How striking the scene when *we first observe* the fiery rays which the

sun scatters among the clouds, as harbingers of his approach. As the illumination increases, the earth seems all in a glow, and we expect the glorious orb long before he discovers himself above the horizon. We imagine, every moment, that we see him. At length he appears. His rays dart, like lightning, over the face of Nature, and darkness vanishes at the sight. Man glories in his habitation, and beholds it embellished with renovated beauty. The lawn is refreshed by the coolness of the night, and the light of the morning displays its increasing verdure. The dew-bespangled flowers that enamel its surface glitter in the sunbeams, and, like rubies and emeralds, dart their colours on the eye. The cheerful birds unite in choirs, and hail, in concert, the parent of life. At this enchanting moment, not one is silent. All Nature is enlivened by his presence, and gladdened by his gifts. Millions of glittering insects awake into existence, and flutter in his rays. The bleating flocks, and lowing herds, salute the welcome blessing. The hills, the valleys, and the woods, resound with rural harmony. All that is vocal unites in the general choir; and all that has breath exults in the enlivening influence. In man, in particular, the assemblage of so many pleasing objects imparts a glowing sensation, that seems to penetrate the soul. Who, indeed, can withstand the rapture of this short interval of enchantment? Who can behold with indifference a scene, at once so magnificent, so beautiful, and so delightful?—But I am aware that, in my morning walk, I have already expatiated on this scene; a scene, however, productive of a pleasure that will ever bear repetition, and of a variety that never can be exhausted.

The sun, that radiant orb, with which, as a part of the planetary system<sup>1</sup> to which our globe belongs,

<sup>1</sup> See No. VII, *Reflections on the Solar System.*

we are so intimately connected, is defined, with respect to us, to be that great luminary which enlightens the world, and whose presence constitutes the day. In the infancy of astronomy it was reckoned among the planets; but it is now numbered among the fixed stars. It appears bright and large in comparison with them; because we keep constantly near the sun, and are at an immense distance from the stars: for a spectator, placed as near to any star as we are to the sun, would see that star a body as large and bright as the sun appears to us; and a spectator, as far distant from the sun as we are from the stars, would see the sun as small as we see a star, divested of all its circumvolving planets; and, in numbering the stars, he would reckon it among them.

The figure of the sun is a spheroid, higher under the equator than about the poles. His diameter is computed to be 894,000 miles. His solid bulk is 24 million of times as big as that of the moon, and half a million of times bigger than that of the earth. His distance from the earth, in round numbers, is about 95 millions of miles; a distance so prodigious, that a cannon-ball, which moves at the rate of about eight miles in a minute, would be something more than twenty-two years in going from the earth to the sun. This account of the diameter, magnitude, and distance of the sun, is deduced from the determinations of the most eminent astronomers in Europe, who were sent out to the most convenient parts of the earth, for the purpose of observing the transits of Venus over the sun, in the years 1761 and 1769.

The sun was generally considered by the ancients as a globe of pure fire; but, from a number of maculæ, or dark spots, which, by means of a telescope, may be seen on different parts of his surface, it appears that this opinion was ill-founded. The spots



consist, in general, of a nucleus, or central part, which appears much darker than the rest, and seems to be surrounded by a mist or smoke; and they are so changeable in their situation and figure, as frequently to vary during the time of observation. Some of the largest of them, which are found to exceed the bulk of the whole earth, are often to be seen for three months together: and, when they disappear, they have been supposed to be converted into faculæ, or luminous spots, which appear much brighter than the rest of the sun<sup>1</sup>. About the time that the solar spots were first discovered by Galileo, forty or fifty of them might be frequently seen on the sun at a time; but, at present, we can seldom observe more than thirty; and there have been periods of seven or eight years in which none could be seen.

Various have been the opinions concerning the nature, origin, and situation of the solar spots. It

<sup>1</sup> But this conversion of the maculæ, or dark spots, into the faculæ, or luminous ones, has been denied. Hevelius, indeed, supports the opinion; but Huygens declares, that he was never able to discover any faculæ; and that all the foundation that he could see for the notion was, that in the darkish clouds that frequently surround the maculæ, little points, or sparks, brighter than the rest, are sometimes discerned. Many authors, after Kircher and Scheiner, have generally represented the sun's body full of bright, fiery spots, which they conceive to be a sort of volcanos in the body of the sun; but Huygens, and others of the latest and best authority, finding that the best telescopes discover nothing of the matter, agree to explode the notion of faculæ. The cause of what have been supposed to be such they attribute to the tremulous agitation of the vapours near our earth; the same as sometimes shows a little unevenness in the circumference of the sun's disk when viewed through a telescope. Strictly, then, the faculæ are not eruptions of fire and flame, but refractions of the sun's rays in the rarer exhalations, which, being condensed in the neighbourhood of that shade, seem to exhibit a light greater than that of the sun.



has been imagined, that the maculæ are occasioned by smoke and opaque matter thrown out by volcanos or burning mountains of immense magnitude; and that when the eruption is nearly ended, and the smoke dissipated, the fierce flames are exposed, and appear like faculæ or luminous spots. M. de la Hire imagined the Sun to be in a continual state of fusion, and that the spots which we observe, are only the eminences of large masses of opaque matter, which, by the irregular agitations of the fluid, sometimes swim upon the surface, and sometimes sink and disappear. Others have supposed them to be occasioned by a number of planets circulating round the sun, at a small distance from his surface. But Dr. Alexander Wilson, by attending particularly to the different phases presented by the umbra, or shady zone, of a spot of an extraordinary size, that appeared upon the sun in November 1769, during its progress over the solar disk, was led to form a new and singular conjecture concerning the nature of these appearances: which he seems afterward to have confirmed and established by repeated observations. The results of these observations are, that the solar maculæ are cavities in the body of the sun; that the nucleus, as the middle or dark part has been usually called, is the bottom of the excavation; and that the umbra, or shady zone, usually surrounding it, is the shelving sides of the cavity. Dr. Wilson appears not only to have ascertained the reality of these immense excavations in the body of the sun, but to have pointed out a method of measuring the depth of them. He estimates, in particular, that the nucleus, or bottom of the large spot above-mentioned, was not less than a semi-diameter of the earth, or about 4000 miles below the level of the sun's surface; while its other dimensions were of a much larger extent. From his observations it may be further inferred, that the body of the

sun, in the depth of the nucleus, either emits no light, or emits so little as to appear dark, when seen at the same time, and compared with that resplendent, and probably, in some degree, fluid substance which covers his surface. This manner of considering these phenomena naturally gives rise to many curious speculations and inquiries. It is natural to inquire, for instance, by what great commotions this refulgent matter is thrown up on all sides, so as to expose to our view the darker part of the sun's body, which was before covered by it? What is the nature of this shining matter? And why, when the excavation is formed in it, is the lustre of this shining substance, which forms the shelving sides of the cavity, so far diminished, as to give the whole the appearance of a shady zone, or darkish atmosphere, surrounding the denuded part of the sun's body? But for a more ample detail of Dr. Wilson's observations on the whole subject, I must refer my readers to the Philosophical Transactions, vol. lxiv; as well as to Dr. Herschel's suggestions of a kindred theory, in different volumes of the same national work.

The motion of the maculæ is from east to west, and as they are observed to move quicker when they are near the central regions, than when they are near the limb, it follows that the sun must be a spherical body, and that he revolves on his axis. The time in which he performs this revolution, as observed by Cassini, is 25 days, 14 hours, and 8 minutes.

Beside the solar spots, the zodiacal light is a singular phenomenon which accompanies the sun, and is usually attributed to his atmosphere. It begins to appear a little before sunrise, and seems at first like a faint, whitish zone of light, resembling the milky way, with its borders ill terminated, and scarcely to be distinguished from the twilight, which

is seen commencing near the horizon. It is then but little elevated, and its figure nearly agrees with that of a flat lenticular spheroid, seen in profile. As it rises above the horizon, it becomes brighter and larger to a certain point, after which the approach of day renders it gradually less apparent, till it becomes quite invisible.

From this philosophical account of the sun, and the principal phenomena which he exhibits, the next and most obvious inquiry is into his pervading energy and essential importance in the creation, and particularly to our globe. But nothing can equal what Thomson has said upon this subject, in his beautiful Hymn to the Sun, at the commencement of his 'Summer.' I refer my readers, therefore, to this, not only as a poetical illustration, but as the noblest account that has ever been given, of the dignity, use, and beauty of this resplendent orb.

Dr. Herschel supposes that the spots in the sun are mountains on its surface, which, considering the great attraction exerted by the sun upon bodies placed at its surface, and the slow revolution it has about its axis, he thinks may be more than 300 miles in height, and yet stand very firmly. He says that in 1792, he examined the sun with several powers from 90 to 500; and it evidently appeared, that the black spots are the opaque ground or body of the sun; and that the luminous part is an atmosphere, which being intercepted or broken, gives us a glimpse of the sun itself. Hence he concludes, that the sun has a very extensive atmosphere, which consists of elastic fluids that are more or less lucid and transparent, and of these the lucid ones furnish us with light. This atmosphere he imagines to be somewhere between 1800 and 2780 miles in height; and he supposes that the density of the luminous solar clouds need not be exceedingly more than that of our aurora borealis, in order to produce the effects



with which we are acquainted. The sun, then, appears to be a very eminent, large, and lucid planet, the first and only primary one belonging to our system. Its similarity to the other globes of the solar system, with regard to its solidity; its atmosphere; its surface diversified with mountains and valleys; its rotation on its axis; and the fall of heavy bodies on its surface; lead us to conclude that it is most probably inhabited, like the other planets, by beings whose organs are adapted to the peculiar circumstances of the vast globe.

By analogical reasoning, likewise, we infer that the moon and planets are the abodes of happiness to indefinite numbers of animated, and, perhaps, rational and intelligent creatures, who may speculate and reason upon our supposed existence as we do of theirs; who may be pursuing scientific knowledge in a way similar to our Newtons, Herschels, and Davys. To take the moon, for instance, and what is applicable to her may, unquestionably, be inferred of the superior planets, and of their moons or satellites also.

The moon is a secondary planet of considerable magnitude; its surface is, as we have seen, diversified, like that of the earth, with hills and valleys. Its situation with respect to the sun, is much like that of the earth; and, by a rotation on its axis, it enjoys an agreeable variety of seasons, and of day and night. To the moon, our globe would appear a capital satellite, undergoing the same changes of illumination as the moon does to the earth. The sun, planets, and the starry constellations of the heavens, will rise and set there as they do here; and heavy bodies will fall on the moon as they do on the earth. There seems, then, only to be wanting, in order to complete the analogy, that it should be inhabited like the earth.

It may be objected, that, in the moon, there are

no large seas; and its atmosphere (the existence of which is doubted by many) is extremely rare, and unfit for the purposes of animal life; that its climates, its seasons, and the length of its days and nights, totally differ from ours; that without dense clouds, which the moon has not, there can be no rain, perhaps no rivers and lakes.

In answer to this it may be observed, that the very difference between the two planets strengthens the argument. We find, even on our own globe, that there is a most striking dissimilarity in the situation of the creatures that live upon it. While man walks on the ground, the birds fly in the air, and the fishes swim in the water. We cannot, surely, object to the conveniences afforded by the moon, if those that are to inhabit its regions are fitted to their conditions as well as we on this globe of ours. The analogy already mentioned establishes a high probability that the moon is inhabited. Suppose, then, an inhabitant of the moon, who has not properly considered such analogical reasonings as might induce him to surmise that our earth is inhabited, were to give it as his opinion, that the use of that great body, which he sees in his neighbourhood, is to carry about his little globe, in order that it may be properly exposed to the light of the sun, so as to enjoy an agreeable and useful variety of illumination, as well as to give it light by reflection, when direct light cannot be had; should we not condemn his ignorance and want of reflection? The earth, it is true, not only performs those offices which have been named, for the inhabitants of the moon, but we know that it also affords magnificent dwelling-places to numberless intelligent beings.—From experience, therefore, we affirm, that the performance of the most salutary offices to inferior planets is not inconsistent with the dignity of superior purposes; and in consequence of such analogical reasonings,



assisted by telescopic views, which plainly favour the same opinion, we do not hesitate to infer, that the sun, also, is richly stored with inhabitants.

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## NO. XLIV.

### ON THE NATURE OF LIGHT.

Fairest of beings! first created light!  
 Prime cause of beauty! for from thee alone,  
 The sparkling gem, the vegetable race,  
 The nobler worlds that live and breathe, their charms,  
 The lovely hues peculiar to each tribe,  
 From thy unfading source of splendour draw!  
 In thy pure shine, with transport I survey  
 This firmament, and those her rolling worlds,  
 Their magnitudes and motions.

MALLET.

WE experience, every moment, the utility of that light which invests our globe; but there is not a subject, concerning the nature of which such a variety of opinions have been formed. Light is defined to be that sensation occasioned in the mind by the view of luminous bodies; or, that property in bodies, whereby they are fitted to excite those sensations in us. The Greeks considered light as an accident, or property, resulting from the first principles of things; and Des Cartes defines it to be a globulous matter diffused through the universe; which being impelled by the sun, strikes upon our eyes, in the same manner as a staff, that is pushed at one end, presses in the same instant at the other. But Des Cartes, and the ancient philosophers, in particular, spoke the language of hypothesis and conjecture: mortal Newton had

recourse to experiment and observation. The rays of light, according to him, are small corpuscles, or particles of matter, emitted with exceeding celerity from the luminous body; with a velocity so immense, indeed, as to enable them to move at the inconceivable rate of 11,000,000 miles in a minute. Mr. Roemer, a Danish philosopher, was the first who showed, that light is about eight minutes in its passage from the sun to the earth. This idea was first suggested to him, by observing the eclipses of Jupiter's moons, by which it appeared, to a demonstration, that the motion of light is not instantaneous, but progressive, or such as would carry it through a space equal to the radius, or semi-diameter of the earth's annual orbit in about eight minutes of time: so that if the sun were annihilated, we should see him for eight minutes afterward, and if he were created again, it would be eight minutes before we should see him. The minutest particles, which are thrown off from the body of the sun, move through a space of 95,000,000 miles in eight minutes, which is about a million of times swifter than the motion of a cannon-ball, when it is first projected from the mouth of the piece: a rapidity too great for the imagination to follow, or the mind to comprehend.

The wonderful divisibility of the parts of matter is no where more apparent, than in the minuteness of the particles of light. Dr. Nieuwentyt has computed, that an inch of candle, when converted into light, becomes divided into 269,617,040 parts, with 40 ciphers annexed; at which rate there must issue from it, when burning, 418,660 particles, with 39 ciphers more, in the second of a minute; which is vastly more than a thousand times a thousand million times the number of sands the whole earth can contain; reckoning ten inches to one foot, and that 100 sands are equal to one foot,

It must be acknowledged, that many difficulties and objections have been urged against the materiality of light, or the hypothesis of light, consisting of small particles emitted from luminous bodies; and that many eminent philosophers, both foreigners and English, have recurred to the opinion, that light consists of vibrations propagated from the luminous body, through a subtile ethereal medium. Among these are the names of Euler and Franklin, whose arguments have been combated by Dr. Horsley, Mr. Melville, and others. But an account of their reasonings on this subject would necessarily lead me into a disquisition much too abstruse for the popular and intelligible manner in which I wish to conduct this paper. Sir Richard Blackmore, in his *Creation*, thus alludes to the difficulties which attend the subject :

Behold the light emitted from the sun!  
 What more familiar, and what more unknown?  
 While by its spreading radiance it reveals  
 All Nature's face, it still itself conceals.  
 See how each morn it does its beams display,  
 And on its golden wings bring back the day!  
 How soon th'effulgent emanations fly  
 Through the blue gulf of interposing sky!  
 How soon their lustre all the region fills,  
 Smiles on the valleys, and adorns the hills:  
 Millions of miles, so rapid is their race,  
 To cheer the earth, they in few moments pass.  
 Amazing progress! At its utmost stretch,  
 What human mind can this swift motion reach?  
 But if, to save so swift a flight, you say,  
 The ever rolling orb's impulsive ray  
 On the next threads and filaments does bear,  
 Which form the springy texture of the air;  
 That those still strike the next, till to the sight  
 The quick vibration propagates the light;  
 'Tis still as hard, if we this scheme believe,  
 The cause of light's swift progress to conceive.

That light, however, is a real substance, notwithstanding the objections that have been urged



against this hypothesis, seems to be established by the phenomena of the Bolognian stone, and of other substances, which possess the remarkable property of imbibing light, of retaining it for some time, and afterward of emitting it<sup>1</sup>.

The doctrine of the materiality of light is further confirmed by those experiments, which demonstrate, that the colour and inward texture of some bodies are changed, in consequence of their being exposed to the light. Among various observations of this kind, was that made by M. Duhamel, who found that the juice of a certain shellfish in Provence contracted a fine purple colour when exposed to the light of the sun, and that the stronger the light, the more splendid was the colour. Pieces of cloth, dipped in this liquor, and exposed to the sun, became red, although they were inclosed in glass; but they acquired none of this colour in the same exposure, if they were covered with the thinnest plates of metal.

<sup>1</sup> Phosphorescent-stone is found on different eminences around Bologna in Italy, and especially on Monte Paderno, loose and scattered about between gypseous stones in a marly earth. It is found most readily after heavy rains, in the streams which run down the sides of the hill. To render it capable of shining in the dark, a piece particularly heavy, fossilaceous, and pure must be selected. After being made red-hot, it is pounded and reduced to a fine powder, which, by means of a solution of gum-tragacanth, becomes a kind of paste, and is then converted into small cakes. When these are dried, they are brought to a state of ignition between coals, and then suffered to cool; after which they are preserved from the air and moisture in a close vessel. If one of these cakes be exposed a few minutes to the light, and then carried into a dark place, it will shine like a burning coal. This power of emitting light becomes lost in the course of time; but it may be restored at first by heating, and afterward by exposure again to ignition. It was discovered at the beginning of the seventeenth century by a shoe-maker of the name of Vincentio Casciarola. See further in *Beckmann's Inventions*, vol. iv. p. 418. 2d edit.

The expansion or extension of any portion of light is inconceivable. Dr. Hook shows, that it is as unlimited as the universe; proving it from the immense distance of some of the fixed stars, the light of which becomes sensible to the eye, by means of a telescope. He adds, that they are not the great bodies only of the sun or stars that are thus liable to disperse their light through the vast expanse of the universe, but the smallest spark of a lucid body must do the same, even the smallest globule struck from a steel by a flint.

Sir Isaac Newton observes, that bodies and light act mutually upon each other; bodies on light, in emitting, reflecting, refracting, and inflecting it; and light on bodies, by heating them, and putting their parts into a vibrating motion, in which heat principally consists. For all fixed bodies, he observes, when heated beyond a certain degree, emit light, and shine; which shining, &c. appears to be owing to the vibrating motions of their parts; and all bodies, abounding in earthly and sulphureous particles, if sufficiently agitated, emit light, which way soever that agitation be effected. Thus, sea-water shines in a storm; quicksilver, when shaken in vacuo; cats, or horses, when rubbed in the dark; and wood, fish, and flesh when putrefying.

Light proceeding from putrescent animal and vegetable substances, as well as from glowworms, is mentioned by Aristotle. Bartholin names four kinds of luminous insects, two with wings, and two without; but it is asserted by travellers, that in hot climates, they are found in much greater numbers, and of different species. In particular, on the river Menam, which runs through Siam, a vast number of those insects, called fire-flies, make a beautiful appearance in the night:

On Menam's orient stream, that nightly shines  
With insect lamps.

THOMSON.



There is one property of light, called *refraction*, which I will mention here, because it is capable of a very easy and familiar illustration, and will account for a very common, but seemingly extraordinary phenomenon. When a ray of light passes out of one medium into another, it is refracted, or turned out of its first course, according as it falls more or less obliquely on the refracting surface which divides the two mediums. Any person may exemplify this by the following experiment: put a shilling in an empty basin, and retire to such a distance, that the edge of the basin shall just hide it from your sight; then keeping yourself steady, let another person fill the vessel gently with water; and, as the water rises toward the top, the shilling will become more and more visible, till, at length, the whole of it will be distinctly seen, appearing as if it had been raised above the bottom of the basin.

This proves, that the rays of light are refracted, or bent downward, in their passage out of the water into the air; and as they now come to the eye in a more oblique direction, the object must necessarily appear to be elevated, and in a different situation from that in which it was really placed. The same thing may also be shown thus: place the basin in such a manner, that the sun may shine obliquely on it, and observe where the shadow of the rim falls upon the bottom; then fill it with water, and the shadow will not extend so far as it did when the vessel was empty; which shows that the rays have changed their direction, by passing out of one medium into another of a different density.

The less obliquely the rays fall, the less they will be refracted; and if they fall perpendicularly, they will not be refracted at all. For, in the last experiment, the higher the sun rises, the less will be the difference between the places, where the edge of the shadow falls, in the empty and full basin. And

if a stick be laid across the basin, and the sun's rays be reflected perpendicularly into it from a looking-glass, the shadow of the stick will fall upon the same part of the bottom, whether the basin be full or empty. The same effects will also take place, when the experiment is performed with any other fluid: but the denser the medium, the more will light be refracted in passing through it.

From these observations it will readily appear, that objects can seldom be seen in their true places. We are deceived by every thing around us: the sight is no less subject to error than the rest of our senses; though they all contribute to our pleasure, and promote our happiness by various means. In consequence of this property of refraction, we enjoy the sight of the sun when he is really below the horizon, for a little time before his rising and for a little time after his setting. This is also the cause which produces the crepusculum, or morning and evening twilight: for the rays of the sun, in falling upon the higher part of the atmosphere, are reflected back to our eyes, and form a faint light, which gradually augments till it becomes day. It is in those brilliant colours which paint the clouds, before the rising of the sun, that the poets have placed *Aurora*, or the goddess of the morn: she opens the gates of day with her rosy fingers; and the daughter of the Air and of the Sun has her throne in the atmosphere.

Had no such atmosphere existed, the rays of light would have come to us in straight lines, and the appearance and disappearance of the sun would have been instantaneous; we should have had a sudden transition from the brightest sunshine to the most profound darkness, and from thick darkness to a blaze of light. Refraction, therefore, is extremely useful, not only as it prepares us gradually for the light of the sun, but as it occasions twilight, and

thus prolongs the duration of the day. Nature has established these gradations, to heighten our pleasures by variety; the scene is perpetually changing, but the order of things is immutable.

With what exalted sentiments of devotion ought the Contemplative Philosopher to consider the various and unspeakably beautiful phenomena of light! We find it to be little less than the life and pleasure of all animated beings. Of what benefit, indeed, could life be; what pleasure, what comfort could we enjoy, in the horrors of perpetual darkness? How could we provide ourselves with food, and the other necessities of life? How could we transact the least business? How could we correspond with each other, or be of the least reciprocal service, without light, and those admirable organs of the body, which the Omnipotent Creator has adapted to the perception of this inestimable benefit?

But it is unnecessary to enumerate the inexpressible advantages of a blessing, of which the most inattentive of mankind must be sensible. What is applied to Wisdom, in the book called *The Wisdom of Solomon*, 'She is a pure influence flowing from the glory of the Almighty—she is the brightness of the everlasting Light,' has been applied by Milton to Light, with the most beautiful propriety:

Bright effluence of bright essence increate.

In a word, when we consider the wonderful beauty and pleasures of which light is the essential source, with how much is still involved in mystery, notwithstanding the most diligent inquiries into its nature and properties, by the most illustrious philosophers, well may we exclaim in the beautiful language of Thomson:

How then shall I attempt to sing of Him  
Who, Light Himself, in uncreated light

Invested deep, dwells awfully retired  
 From mortal eye, or angel's purer ken ;  
 Whose single smile has, from the first of time,  
 Filled, overflowing, all yon lamps of heaven,  
 That beam for ever through the boundless sky :  
 But, should He hide his face, th' astonished sun,  
 And all th' extinguished stars, would loosening reel  
 Wide from their spheres, and Chaos come again.

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No. XLV.

ON COLOURS.

Colours are but the phantoms of the day,  
 With that they're born, with that they fade away ;  
 Like beauty's charms, they but amuse the sight,  
 Dark in themselves, till by reflection bright ;  
 With the sun's aid to rival him they boast,  
 But light withdrawn, in their own shades are lost.

HUGHES.

THE inquiry, in my former paper, into the nature and properties of light, leads me to consider next the admirable relations which the Deity has established between light itself and the surfaces of different bodies, whence proceed the various phenomena of colours.

Different are the opinions of ancient and modern authors, and of the several sects of philosophers, with regard to the nature and origin of the phenomenon *colour*. The most popular opinion was long that of Aristotle, who maintained colour to be a property residing in the coloured body, and to exist independently of light. But to this doctrine it was



objected, that the neck and feathers of a pigeon or a peacock change their colours, according to their positions. Thus Lucretius :

*Pluma columbarum quo pacto in sole videtur, &c.*

*LIB. II. 800—806.*

The plumes that go around the pigeon's head  
Sometimes look brisker with a deeper red ;  
And then, in different positions seen,  
Show a gay sky, all intermixed with green :  
And so in peacock's tails, all filled with light,  
The colour varies with the change of site. CREECH.

It is now universally admitted, that colour is a property inherent in light, whereby, according to the different sizes and magnitudes of its parts, it excites different vibrations in the fibres of the optic nerve ; which, propagated to the sensorium, affect the mind with different sensations. Or colour may be defined a sensation of the soul, excited by the application of light to the retina of the eye ; and different, as that light differs in the degree of its refrangibility, and the magnitude of its component parts.

The philosophy of colours is not unnoticed by the poets : Cowley, in particular, thus addresses Light, in a beautiful hymn :

All the world's bravery, that delights our eyes,  
Is but thy several liveries :  
Thou the rich die on them bestow'st,  
Thy nimble pencil paint'st the landscape as thou go'st.

A crimson garment in the rose thou wear'st ;  
A crown of studded gold thou bear'st ;  
The virgin lilies, in their white,  
Are clad but with the lawn of almost naked light.

The violet, Spring's little infant, stands  
Girt in thy purple swaddling-bands :  
On the fair tulip thou dost doat ;  
Thou cloth'st it in a gay and party-coloured coat.

With flame condensed thou dost thy jewels fix,  
 And solid colours in it mix ;  
 Flora herself envies to see  
 Flowers fairer than her own, and durable as she.

Thus Thomson in his description of the rainbow :

Refracted from yon eastern cloud,  
 Bestriding earth, the grand ethereal bow  
 Shoots up immense ; and every hue unfolds,  
 In fair proportion running from the red,  
 To where the violet fades into the sky.  
 Here awful Newton, the dissolving clouds  
 Form, fronting on the sun, thy showery prism ;  
 And to the sage-instructed eye unfold  
 The various twine of light, by thee disclosed  
 From the white mingling maze.

And more copiously still, in his poem to the memory of that divine philosopher :

Light itself, which every thing displays,  
 Shone undiscovered, till his brighter mind  
 Untwisted all the shining robe of day ;  
 And, from the whitening undistinguished blaze,  
 Collecting every ray into his kind,  
 To the charmed eye educed the gorgeous train  
 Of parent colours. First the flaming red  
 Sprung vivid forth ; the tawny orange next ;  
 And next delicious yellow ; by whose side  
 Fell the kind beams of all refreshing green.  
 Then the pure blue, that swells autumnal skies,  
 Ethereal played ; and then, of sadder hue,  
 Emerged the deepened indigo, as when  
 The heavy-skirted evening droops with frost.  
 While the last gleamings of refracted light  
 Died in the fainting violet away.  
 These, when the clouds distil the rosy shower,  
 Shine out distinct adown the watery bow ;  
 While o'er our heads the dewy vision bends  
 Delightful, melting on the fields beneath.  
 Myriads of mingling dyes from these result,  
 And myriads still remain ; infinite source  
 Of beauty, ever blushing, ever new !

But from poetical illustrations I shall proceed to a more minute discussion of this subject. A ray of light falling upon a glass prism, breaks there, and is divided into seven principal rays, each of which bears its proper colour. The oblong image which this sort of refraction produces, affords seven coloured stripes, distributed in a regular order. The first, reckoning from the upper part of the image, is red; the second, orange; the third, yellow; the fourth, green; the fifth, blue; the sixth, indigo; the seventh, violet. These stripes do not glare; but the eye passes from the one to the other by gradations or shades.

The rays which bear the highest colours, as the red, orange, and yellow, are those that break, refract, or curve the least in the prism. They are also such as reflect the first, on inclining the instrument. And hence it follows, that each ray has its essence or degree of refrangibility. If one of these rays is made to pass through several prisms at the same time, it will afford no new colours, but will constantly retain its primitive colour. This is an invincible proof of its immutability; for colours are not merely modifications arising from refraction or reflection, but immutable properties, and such as belong to the nature of the rays.

If a lens be presented to seven rays divided by the prism, they will be reunited into a single ray, which will exhibit a round image of a shining white. If only five or six of these rays be taken with the lens, it will produce but a dusky white. Two rays only reunited, will afford a colour that partakes of both. A stream of light, therefore, is a cluster of seven rays, whose reunion forms white, and the division of which produces seven principal and immutable colours.

What then is the source of that infinite diversity of colours, *which causes such variety in bodies, and*

embellishes every part of our abode? From certain *lamellæ*, or thin particles, that compose the surface of bodies, and which are so many little prisms, variously inclined, that break the light, and reflect different colours. Gold divided into very thin plates, appears blue, when opposed to broad daylight. Those matters which corrode and split the mass of parts, change their complexions; and, consequently, the greater or less thickness of the *lamellæ* or thin plates, contributes likewise to the diversity of colours.

Whence proceeds that beautiful azure which tinges the canopy of heaven?—The ground of the heavens is black; and this ground viewed through the body of air that surrounds us, must appear blue to us by transmission.

Whence proceeds the smiling verdure that adorns the fields, and delights the eye? The *lamellæ* of the surface of plants are made and disposed in such a manner, that they emit only green rays, while they afford a free passage to other rays. If green more particularly please the sight, it is because it holds an exact medium between the seven principal colours. But who can be insensible of the care that Nature has taken to depart from uniformity in this case, by multiplying the shades of green into such an infinite variety? Some writers of great distinction have made it an argument for Providence, that the whole earth is covered with green rather than with any other colour, as being such a right mixture of light and shade, that it comforts and strengthens the eye, instead of weakening and grieving it. The poets, therefore, apply to this particular colour the epithet *cheerful*; and by Thomson it is thus apostrophized:

Gay Green!

Thou smiling Nature's universal robe!

United light and shade! where the sight dwells

With growing strength, and ever new delight!



The rainbow, that beautiful phenomenon, displays at once all the colours of the prism. How enchanting are the beauty and vivacity of its shades! One might imagine that Nature must have been at a vast expense to form such a magnificent arch; but philosophy teaches us, that some drops of water, on which the light breaks and reflects in different angles, are the sole cause of the glorious spectacle.

What splendour in the gilding of some insects! What richness in the scales of fishes! Nature, always magnificent in design, but frugal in execution, produces these brilliant decorations with little cost. She applies only a brown and pretty thin skin on a whitish substance: this skin performs the office of varnish to our gilded skins: it modifies the rays which issue from the surface it covers. These observations have been extended also to the leaves of plants, the enamelling of flowers, and to the colouring of fruits. In a word, the nature, origin, and properties of colours, in all their infinite varieties, would afford inexhaustible subjects of contemplation; curious to the speculative inquirer, and instructive to the virtuous philosopher.

The sun's rays, the great source of light and heat to the world, have been found by Dr. Herschel to contain, besides all the common coloured rays, separable by the prism, a number of rays of mere heat, giving no light, still less refrangible than the red rays of the spectrum formed by the prism; extending, therefore, beyond them, and producing a greater heat than any of the coloured rays. It has, further, been discovered, as appears both by the experiments of Dr. Wollaston and of Mr. Ritter, that beyond the opposite or violet side of the prism, are certain other rays, also invisible, which do not affect the thermometer, but which produce some of the chemical effects of the visible rays of light, particularly of the violet rays to which they are contiguous.

These, therefore, are rays which, though they do not illuminate, agree in chemical properties with those that do, and are *calorific* solely, not *colorific*.

I shall conclude this philosophical disquisition with some moral reflections from an elegant writer, who adduces the beauty so apparent in the whole creation, as an argument of the benignity of the Great Creator to mankind. 'He has made every thing that is beautiful in all other objects pleasant, or rather has made so many objects appear beautiful, that he might render the whole creation more gay and delightful. He has given almost every thing about us the power of raising an agreeable idea in the imagination: so that it is impossible for us to behold his works with coldness or indifference, and to survey so many beauties without a secret satisfaction and complacency. Things would make but a poor appearance to the eye, if we saw them only in their proper figures and motions. And what reason can we assign for their exciting in us many of those ideas which are different from any thing that exists in the objects themselves (for such are light and colours) were it not to add supernumerary ornaments to the universe, and make it more agreeable to the imagination? We are every where entertained with pleasing shows and apparitions, we discover imaginary glories in the heavens and in the earth, and see some of this visionary beauty poured out upon the whole creation; but what a rough unsightly sketch of nature should we be entertained with, did all her colouring disappear, and the several distinctions of light and shade vanish? In short, our souls are at present delightfully lost and bewildered in a pleasing delusion; and we walk about like the enchanted hero in a romance, who sees beautiful castles, woods, and meadows; and, at the same time, hears the warbling of birds, and the purling of streams; but upon the finishing of some secret spell, the fantastic scene

ks up, and the disconsolate knight finds himself  
 barren heath, or in a solitary desert. It is not  
 probable but something like this may be the state  
 of the soul after its first separation, in respect to the  
 senses it will receive from matter; although, in-  
 deed, the ideas of colours are so pleasing and beau-  
 tiful in the imagination, that it is possible the soul  
 may not be deprived of them, but perhaps find them  
 excited by some other occasional cause, as they are,  
 excited, by the different impressions of the subtle  
 matter on the organs of sight.

These reflections, which discover such a delicate  
 sensibility to the beauty of nature, and which con-  
 stitute such a happy illustration of the author's idea,  
 are grounded upon the doctrine of Mr. Locke, that  
 all our ideas of colours, as apprehended by the imagina-  
 tion, are only ideas in the mind, and not qualities  
 which have any existence in matter.

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## No. XLVI.

### ON VISION.

With thought from prepossession free, reflect  
 On solar rays, as they the light respect.  
 The beams of light had been in vain displayed,  
 Had not the eye been fit for vision made :  
 In vain the Author had the eye prepared  
 With so much skill, had not the light appeared.

BLACKMORE.

Oculi - - - Interpretes ac Nuntii Rerum.

CICERO.

LUCRETIVS is the only bard I can recollect  
 who has ornamented the philosophy of vision with

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poetical illustration. But his theory, which was that of his master Epicurus, however beautiful in poetry, has long vanished before the accurate researches and superior attainments of the moderns.

If the construction of the universe were not so evident a proof of the existence of a supremely wise and benevolent Creator, as to render particular arguments unnecessary, the structure of the eye might be offered as one, by no means the least. This instance, among numberless others, demonstrating, that the most exquisite performances of art are infinitely short of those which are continually produced by the Divine Mechanic.

Of all the senses, the sight is that which furnishes the soul with the quickest, most extensive, and most varied perceptions. It is the fertile source of the richest treasures of imagination, and it is to that principally, that the soul owes the ideas of beauty, and of that *varied unity* which enchants it.

‘ Our sight (as observed by an admirable writer) is the most perfect and delightful of all our senses. It fills the mind with the largest variety of ideas, converses with its objects at the greatest distance, and continues the longest in action, without being tired or satiated with its proper enjoyments. The sense of feeling can indeed give us a notion of extension, shape, and all other ideas that enter at the eye, except colours; but, at the same time, it is very much straitened and confined in its operations, to the number, bulk, and distance of its particular objects. Our sight seems designed to supply all these defects, and may be considered as a more delicate and diffusive kind of touch, that spreads itself over an infinite multitude of bodies, comprehends the largest figures, and brings into our reach some of the most remote parts of the universe.’

Night has gradually withdrawn her sable curtain from the face of the earth. Aurora proclaims the



approach of the glorious sun. He appears, and all nature seems to have received a new creation. What majesty! what splendour! what light! what colours!

But by what secret mechanism are my eyes made capable of communicating to me such lively, varied, and infinite perceptions? How do I discover with so much facility and quickness every object that surrounds me?

The eye is composed of several tunics, or coats, one within the other, and is filled within with transparent humours of different refractive densities. The external tunic, called the *sclerotica*, is white on the exterior part, except a circular portion immediately in front, which is transparent, and more convex than the rest of the eye: this transparent part is called the *cornea*. Immediately adherent to the *sclerotica* within, is the *choroides*, or *uvula*, which, at the circumference of the *cornea*, becomes the *iris*, being expanded over great part of its surface, though not contiguous to it. The *iris* is composed of two kinds of muscular fibres; the one softened, like the radii of a circle, toward its centre, and the others form a number of concentric circles round the same centre. The central part of the *iris* is perforated, and the orifice, which is called the *pupil*, is of no constant magnitude; for, when a very luminous object is viewed, the circular fibres of the *iris* contract, and diminish its orifice; and, on the other hand, when objects are dark and obscure, the radial fibres of the *iris* contract, and enlarge the *pupil*, so as to admit a greater quantity of light into the eye. The *iris* is variously coloured in different persons, but according to no certain rule. In general, they whose hair and complexion are light-coloured, have the *iris* blue or gray; and, on the contrary, whose hair and complexion are dark, have of a deep brown. But what specific differ

may occasion in the sense, or whether any at all, is not discoverable. Within the *uvea* is another membrane, which, at the circumference of the *cornea*, becomes fibrous, and is called the *ligamentum ciliare*. This ligature is attached to the circumference of a double convex lens, whose axis corresponds with the centre of the pupil, and which, by means of the fibres, can be altered, in a small degree, in position, and perhaps in figure. This lens is termed the crystalline humour; and is included in a very strong and transparent membrane called the *arachnoides*. Between the crystalline humour and the *cornea* is contained a clear transparent fluid, called the aqueous humour; and between the crystalline humour and the posterior part or bottom of the eye, is included another clear transparent fluid which is called the vitreous humour. The refractive density of the crystalline is greater than those of the humours that surround it. On the side next to the nose, a nerve is inserted in the bottom of each eye, about twenty-five degrees from the axis of the crystalline, which, after entering the eye, is spread into an exceeding fine coat of network, termed the *retina*. Lastly, a very black mucus or slime, is spread over all the internal parts of the eye, that are not transparent, except the anterior part of the *iris*, which, as before observed, is coloured.

From this account of the structure of the eye, I shall proceed to that of vision, or the act of perceiving external objects by the organs of sight. And this is well defined to be a sensation, by which, from a certain motion of the optic nerve, made in the bottom of the eye by the rays of light emitted or reflected from objects, and hence conveyed to the common sensory in the brain, the mind perceives the luminous object, its quantity, quality, figure, &c. And thus, all the modern philosophers, whether Cartesians or Newtonians, agree, that vision is per-

formed by rays of light, reflected from the several points of objects received in at the pupil, refracted and collected in their passage, through the coats and humours before-mentioned, to the retina; and thus striking, or making an impression, on so many points of it; which impression is conveyed to the brain, &c. by the correspondent capillaments, or fibres, of the optic nerve.

The cornea, or second coat of the eye, being of a convex figure, performs the office of a glass lens. To illustrate this by a familiar example, put a glass lens into a hole made in the window-shutter of a dark room; present a pasteboard to this lens at a suitable distance; and you will immediately have a picture, in which all the objects without will be painted to the greatest precision, and according to all the rules of the most exact perspective. It will be like a moving picture whenever these objects move. You will then see rivers rushing down from the tops of mountains, and meandering in the plains; birds hovering in the air; fishes sporting on the surface of the water; flocks frisking in the meadows; and, in fine, all the possible varieties of prospect.

Substitute instead of the lens the real eye of an ox, newly stript of its teguments, and you will see the same picture on the membrane which covers the bottom of it; but all the figures will be painted in a much smaller size. You can never be tired of admiring the extreme delicacy of this piece of miniature, and you will be astonished to behold a field, fifteen or twenty miles square, exactly delineated on a piece of vellum of a few lines in length.

The structure of the eye of an ox is the same, with respect to the essential parts of it, as that of ours; and thus the mechanism of vision is explained. The humours of the eye are the lens of the camera obscura; the retina is the pasteboard.

The black skin, which hangs within the pupil, performs the office of a shutter that excludes the light—it extinguishes the rays whose reflection would render the image less distinct. The pupil, by contracting or dilating itself in proportion to the intensity of the light, moderates the action of the rays on the retina; and the nerve, placed behind this, communicates to the brain, as before observed, the various concussions it receives, and to which various perceptions correspond.

In the theory of vision there are many curious phenomena, which have exercised the ingenuity of the most learned men. Whence comes it, for instance, that all external objects are painted inverted on the retina, and that we see them, nevertheless, in their real situation? Whence is it, that objects of the greatest magnitude are delineated on the eye with extreme minuteness, and yet we perceive every thing in its proper size? Whence is it, that if we look down from the top of St. Paul's cathedral in London, we see beneath us many thousand houses of that great metropolis, each painted so exactly in our eye in a space hardly three times larger than the head of a pin? So many millions of rays enter by a very small aperture; they are united on the retina at the bottom of the eye, without confusion, and constantly preserving the same order which the points of the objects had that emitted them. Let us ascend a high rock, and observe a fleet in full sail at sea; let us contemplate the sea itself, and what millions of waves may be discovered! Each of these, nevertheless, reflects masses of rays upon our eye, the size of which is so minute. In an extensive country prospect, every tree, and even every blade of grass, emits its rays; without which it would be impossible for us to perceive the uninterrupted verdure of all the fields beneath us. Is it not wonderful too, that we do not see objects double; and



that although we have two eyes, each object still appears but one?

But there is another circumstance to excite our admiration. The objects we behold are not visible to us alone: we have just observed, with astonishment, the number of rays they send on a space so small as that occupied by the pupil of the eye. They all send as many more to every part of the mass of air that surrounds them. Wherever, therefore, we may remove, new rays replace the first, and render the same objects visible to us, that we had seen in our former situation. All the rays necessary to effect this had existed before, and waited only for eyes. But the rays admitted into the eye are not all equally efficacious. Beside these, there are innumerable others, which, being much weaker, are effaced by the splendour of the first, but which are constantly ready to perform the same functions, if necessary.

But how few are there who reflect on the wonderful phenomena of vision? From the habit of seeing, the instant we open our eyes, we are apt to regard this operation as a thing extremely simple, and easy to be understood. Nevertheless we are still far remote from an ability to explain all the phenomena of vision. We know, indeed, how the image is formed at the bottom of the eye; we know also, what all the parts of the eye contribute to this. But this is not sufficient; for the eye itself can have no idea of what passes within it. It is necessary, therefore, that the impression which the rays make upon it should be propagated to the brain, and that, to accomplish this, the rays paint the image on a network of nerves which correspond to those of the brain. In this manner, the motion impressed by the rays on the nerves of the retina, is transmitted to the brain by the optic nerve: yond this we can describe no more; for w

perfectly know the nature of the brain, nor the use of its various parts <sup>1</sup>.

We know enough, however, to induce us to admire and to adore the unspeakable power, and wisdom, and goodness of God. Whatever remains inaccessible to our comprehension, is the work of a Supreme Intelligence, conspicuous in every object, whether in ourselves, or in every thing that surrounds us; an Intelligence, which never ceases to employ the wisest means to accomplish the most benevolent ends.—The great philosopher of antiquity, in his treatise *De Naturâ Deorum*, was sensible of the wisdom and contrivance displayed in the construction of the eye: ‘What artificer but Nature, whose direction is incomparable, could so artfully have formed the senses? She has covered and invested the eyes with the finest membranes, which she has made transparent, that we may see through them, and firm in their texture, to preserve the eyes. She has made them slippery and moveable, that they might avoid what would offend them, and easily direct the sight wherever they will. The point of sight, which is called the pupil, is so small, that it can easily shun whatever may be hurtful to it. The eyelids, which are their coverings, are soft and smooth, that they may not injure the eyes, and are made to shut at the apprehension of any accident, or to open at pleasure; and these movements Nature has ordained to be made in an instant. They are fortified with a sort of palisade of hairs, to keep off what may be noxious to them when open, and, when sleep closes them, to be a fence to their repose. Besides, they are commodiously defended by eminences on every side; for,

<sup>1</sup> They who wish to contemplate this subject with philosophical accuracy, should peruse the Rev. Andrew Horn’s ingenious essay entitled ‘The Seat of Vision determined.’

In the upper part, the eyebrows turn aside the sweat that falls from the forehead; the cheeks beneath, having a little rising, protect the lower; and the nose is placed between as a wall of separation.'

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No. XLVII.

ON SOUND AND THE SENSE OF HEARING.

Auditor sonus, et vox omnis, in aures  
Insinuata suo pepulere ubi corpore sensum.

LUCRETIVS.

Mark how the spirits, watchful in the ear,  
Seize undulating sounds, and catch the vocal air.

BLACKMORE.

**SOUND** may be defined to be a perception of the soul, communicated by means of the ear; or the effect of a collision of bodies, and a tremulous motion in consequence of that collision, communicated thence to the circumambient fluid, and propagated through it to the organs of hearing.

To explain this definition I must observe, that when obtuse bodies move in elastic fluids, they condense that part toward which they move, at the same time that the part from which they recede is rarefied. This condensation, or rarefaction, must produce an undulatory or vibrating motion in the fluid. Thus, if a body, by percussion or otherwise, be put into a tremulous motion, every vibration the body will excite a wave in the air, which will proceed in all directions so as to form a

sphere<sup>1</sup>; and the quicker the vibrations of the body succeed each other, the less will be the distance between each successive wave. The sensation excited in the mind by means of these waves, which enter the ear, and produce a like motion in a thin membrane, stretched obliquely across the auditory passage, is called sound. But the term is frequently used to imply, not only the sensation excited in the mind, but likewise the affection of the air, or of the sonorous body by which that sensation is produced. Thus, we say, that a sound is in the air, or that a body sounds when struck, although the affection of the air or body is very different from the sensation.

That bodies move or tremble when they produce sound, requires no particular proof: it is evident in drums, bells, and other instruments, whose vibrations being large and strong are, therefore, more perceptible: and it is equally clear, that a similar vibration is excited in the air, because this vibration is communicated through the air to other bodies, that are adapted to vibrate in the same manner: thus bells, glasses, basins, and musical strings, will sound merely by the action propagated from other sounding bodies.

It is established, as well by mathematical reasoning from the nature of an elastic fluid, as from experiment, that all sounds whatever arrive at the ear in equal times from sounding bodies equally distant, when they are transmitted through atmospheric air. This common velocity is 1142 English feet in a second of time. The knowledge of the velocity of sound is of use, for determining the distances of

<sup>1</sup> The same is visible when a stone is thrown into stagnating water: the waves excited thereby continue some time to rise in the place where the stone fell into the water, and are propagated thence in concentric circles, upon the surface of the water, to great distances.



pe, or other objects: for instance, suppose a ship  
s a gun, the sound of which is heard five seconds  
r the flash is seen; then, 1132 multiplied by 5,  
es the distance 5710 feet, or one mile and 430  
: If sound is transmitted through other gases,  
velocity is greater or less, according to the  
sity and constitution of the gas which con-  
s it.

When the aërial waves meet with an obstacle  
ch is hard, and of a regular surface, they are re-  
ted, and consequently, an ear placed in the course  
hese reflected waves will perceive a sound similar  
he original sound, but which will seem to pro-  
d from a body situate in like position and distance  
ind the plane of reflection, as the real sounding  
y is before it. This reflected sound is called  
echo.

This echo, or repercussion of sounds, is chiefly  
ervable in smooth, tortuous, and hollow places,  
in valleys, caves, and walls, especially in old  
lited buildings. An echo, therefore, as a pleas-  
, and very often wonderful circumstance, could  
fail to enter into poetical descriptions, and to be  
subject of fiction and personification. The He-  
ws styled *Echo the daughter*, and the Greeks  
| Latins, *the image of the voice*. Thus Virgil:

Aut ubi concava pulsu  
Saxa sonant, vocisque offensa resultat imago.

Nor hollow rocks that render back the sound,  
And doubled images of voice rebound. DRYDEN.

d Horace:

Cujus recinet jocosa  
Nomen imago.  
Aut in umbrosis Heliconis oris,  
Aut super Pindo, gelidove in Hæmo.

Whose hallowed name  
 The sportive image of the voice  
 Shall in the shades of Helicon repeat,  
 On Pindus, or on Hæmus ever cool. FRANCIS.

In the third book of Ovid's *Metamorphoses* is the beautiful fiction of the Transformation of Echo to which I must refer the reader; but the following extract from Addison's translation of it affords an admirable description of an echo:

Echo in others' words her silence breaks,  
 Nor speaks herself but when another speaks.  
 She can't begin, but waits for the rebound,  
 To catch his voice, and to return the sound.  
 Hence 'tis she prattles in a fainter tone,  
 With mimic sounds, and accents not her own;  
 Lives in the shady coverts of the woods,  
 In solitary caves, and dark abodes.

But nothing can exceed the exquisite song in Milton's *Comus*:

Sweet Echo, sweetest nymph, that liv'st unseen  
 Within thy æery shell,  
 By slow Meander's margent green,  
 And in the violet-embroidered vale,  
 Where the love-lorn nightingale  
 Nightly to thee her sad song mourneth well;

Canst thou not tell me of a gentle pair  
 That liketh thy Narcissus are?  
 O if thou have  
 Hid them in some flow'ry cave,  
 Tell me but where,  
 Sweet queen of parly, daughter of the sphere,  
 So may'st thou be translated to the skies,  
 And give resounding grace to all Heav'n's harmonies

Milton, moreover, makes a noble poetical use of the philosophy of echoes in Adam's morning hymn:

Witness if I be silent, morn or even,  
To hill or valley, fountain, or fresh shade,  
*Made vocal by my song, and taught his praise.*

And to this he makes Adam pathetically allude, in his lamentation after the fall :

O woods, O fountains, hillocks, dales, and bowers,  
With other, echo late I taught your shades  
To answer and resound far other song !

But I must return to a philosophical discussion of the subject. The waves of sound being thus reflexible, nearly the same, in effect, as the rays of light, may be deflected or magnified, by much the same contrivances as are used in optics. From this principle of reflection it happens, that sounds uttered in one focus of an elliptical cavity are heard much magnified in the other focus ; instances of which are found in several domes and vaults, particularly in the whispering gallery at St. Paul's cathedral in London, where a whisper uttered at one side of the dome is reflected to the other, and may be very distinctly heard. On this principle also is constructed the speaking trumpet, which either is, or ought to be, a hollow parabolic conoid, having a perforation at the vertex, to which the mouth is to be applied in speaking, or the ear in hearing.

But to what purpose would be all these observations on the nature and properties of sound, if the human frame were not made capable of receiving it ? How adorable then is the goodness of the great Creator, in having not only disposed the air in such a manner, that sound may be produced by its vibrations, but in having given us an organ capable of receiving these sonorous vibrations.

<sup>1</sup> An account of some very remarkable echoes, with pleasing observations on this subject, may be seen *Philosophy of Nature*, vol. i. p. 83.

The position of the ear is admirable; for it is placed in the most convenient part of the body, near the brain, the common seat of all the senses, to give the more speedy information; in a part where it can be best guarded; and in the neighbourhood of its sister sense, the eye, with which it has a peculiar and admirable communication by its nerves.

The structure also of the ear, no less than its position, may evince intelligence, wisdom, and design. The ear may be considered as exterior and interior. And if we observe the structure of the exterior ear in all kinds of animals, we cannot but perceive how wonderfully it is adapted to the respective exigencies of each. In man it is of a form proper for the erect posture of his body: in birds, of a form proper for flight, not protuberant, which would obstruct their progress, but close and covered, to afford the easier passage through the air. In quadrupeds, its form is agreeable to the posture, and slower motion, of their bodies; and in these too, various, according to their various occasions: in some, large, erect, and open, to hear the least approach of danger: in others, covered, to keep out noxious bodies. In subterraneous quadrupeds, which are forced to mine and dig for their food and habitation, as a protuberant ear, like that of other quadrupeds, would obstruct their labours, and be liable to be torn and injured, their ears, on the contrary, are short, lodged deep, and backward in the head, passing to the under part of it, and all sufficiently fenced and guarded. To mention one instance only; the mole is, in this respect, a subject of curious discussion: it has no protuberant ear, but only a round hole between the neck and shoulder, and this situation, with the thick short fur, that covers it, is a sufficient defence against all external annoyance.

And, as the form is various in various animals, so, in each of them, its structure is very curious and

able; being admirably contrived to collect the ring circumambient impressions, and undulate of sound, and to convey them to the sensory .—But I shall now confine my survey to the ear.

The first thing we observe is the auricle, or external ear, with its tortuous cavities, formed to stop collect the sonorous undulations, to give them the circulation and refraction, and so convey to the concha, or large capacious round cell, the entrance of the ear. And the great contrivance visible in the outward ear, is in nothing more important than in this circumstance, that they whose ears are cut off, have but a confused way of hearing and are obliged either to form a cavity round their ear with their hand, or else to make use of a trumpet to supply the defect. The cartilaginous substance of the outward ear, is likewise, obviously, another wise provision of the great Creator.

In the interior part of this admirable organ we observe, in the first place, the auditory passage, slightly tunnelled and turned, to give sounds an easy passage, as well as a gentle circulation and return, and likewise to prevent their too furiously striking in, and assaulting the more tender internal

to prevent, moreover, the entrance of noxious vapours, which are apt to make their retreat in every hole, Nature has secured this passage with a viscid nauseous substance, called earwax, which is secreted by the glands appointed for that purpose. The next principal thing to be observed, is the membrana tympani, or drum of the ear, with its membrane, the four little appendant bones, and three inner nodules to move them, and to adapt the whole system to the several purposes of hearing.



ing, to hear loud or soft, discordant or agreeable sounds.

The passage just behind the drum of the ear is called the vestibulum, being, as it were, the antichamber or entrance to two other cavities. The first of these is called the labyrinth, and consists of certain semicircular canals; and the second is called cochlea, from its resemblance to a snail shell. The labyrinth appears to have something of the mechanism and uses of a hearing trumpet; while the cochlea appears to be destined for the more delicate and refined uses of hearing, such as the forming and modulating of musical and harmonious sounds.

There is one particular contrivance of the nerves ministering to the sense of hearing, that must not be passed over; which is, that the branches of one of the auditory nerves spread partly to the muscles of the ear, partly to the eye, partly to the tongue and instruments of speech, and inosculated with the nerves to go to the head and breast. By these means, there is an admirable and useful consent between the parts of the body; it being natural for most animals, upon the hearing of any uncouth noise, to erect their ears, and prepare them to catch every sound; to open their eyes, those constant faithful centinels, to stand upon the watch; and to be ready with the mouth to cry out, and utter what the present exigency may suggest. And this is, accordingly, usual for most animals, when surprised or terrified by any frightful noise.

Such are the nature and properties of sound, and such the admirable structure and uses of the ear. If it be asked why, when a word is pronounced, it excites a certain idea, and not a simple tone; or how a sound can act upon the soul, and produce so many different notions; we are obliged, in this respect, to confess our absolute ignorance.

We know enough, however, to be assured, that the ear is one of the most convincing proofs in nature of the divine wisdom and goodness; and well may we exclaim with the royal Psalmist, '*Such knowledge is too wonderful for me: it is high, and I cannot attain unto it. But I will praise thee, O Lord; for I am fearfully and wonderfully made.*'

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## No. XLVIII.

### ON THE SMELL, TASTE, AND TOUCH.

Next in the nostrils she doth use the Smell,  
As God the breath of life in them did give:  
So makes He now this power in them to dwell,  
To judge all airs whereby we breathe and live.

DAVIES.

Taste after Taste upheld with kindest change.

MILTON.

By Touch the first pure qualities we learn,  
Which quicken all things, hot, cold, moist, and dry;  
By Touch, hard, soft, rough, smooth, we do discern;  
By Touch, sweet pleasure and sharp pain we try.

DAVIES.

BEFORE I enter into a consideration of the remaining senses, the Smell, Taste, and Touch, I shall make some observations upon the Senses in general. By certain wonderful organs of the body, man is susceptible of a variety of sensations. We have seen, that by the eyes, he can acquire the perception of light and colours; and, by the ears, the perception of different tones. By the smell and taste, moreover, he perceives certain agreeable or disagreeable emanations, savours and odours, sweet

and bitter, and other similar properties in the bodies or substances which approach the nose, or are admitted into the mouth. And finally, by the touch, which is diffused over the whole body, he has the sensations of heat and cold, of moist and dry, of soft and hard, &c.

These five senses thus useful to man, and indeed essential to his happiness, have been the subject of poetical illustration, in one of the earliest periods of English versification. Sir John Davies, who flourished in the reign of queen Elizabeth, thus expresses himself, in his excellent poem on the Immortality of the Soul.

This power is sense, which from abroad doth bring  
The colour, taste, and touch, and scent, and sound,  
The quantity and shape of every thing  
Within earth's centre or heaven's circle found :

And though things sensible be numberless,  
But only five the sense's organs be ;  
And in those five all things their forms express,  
Which we can touch, taste, smell, or hear, or see.

\* \* \* \* \*

Then is the soul a nature, which contains  
The power of sense within a greater power,  
Which doth employ and use the sense's pains ;  
But sits and rules within her private bower.

\* \* \* \* \*

If we had nought but sense, then only they  
Should have sound minds which have their senses sound  
But wisdom grows when senses do decay,  
And folly most in quickest sense is found.

The sense next in order, after those of sight and hearing, which we have been already describing, is Smell, which is that whereby we become sensible of odorous bodies. The principal organs of this sense are the nostrils and olfactory nerves; the minute ramifications of which latter are distributed throughout the whole concave of the former.

Smelling is performed by the odorous effluvia, flowing in the air, being drawn into the nostrils, by inspiration, and struck with such force against the fibrillæ of the olfactory nerves, as to shake them, and give them a vibratory motion; which action being communicated thence to the common sensory, occasions an idea of a sweet, or fetid, or sour, or aromatic, or putrified object, &c. And it is observed by the great Boerhaave, that the matter of animals, vegetables, fossils, &c. which chiefly affects the sense of smelling, is that subtile substance, inherent in the oily parts thereof, called *spirits*; because, when this is taken away from the moist fragrant bodies, what remains has scarce any smell at all; but this, poured on the most inodorous bodies, will give them a fragrancy.

Brutes have generally the sense of smelling in much greater perfection than man; as by this alone they distinguish the virtues and qualities of bodies unknown before; hunt out their food at a great distance, as hounds and birds of prey; or find it hid among other substances, as hogs and ducks. But man, having other means of judging of his food, does not need so much sagacity in his nose.

Dr. Derham observes, that although the apparatus for smelling be sufficiently grand and admirable, it is not so complicated as that of the eye and ear; it being sufficient in this sense, that the odoriferous effluvia of bodies have a free and easy passage to the olfactory nerves, without the formalities of refractions, and other preparations necessary to the perfection of the two former senses. And, accordingly, the All-wise Creator has made sufficient provision for the reception of smells, by the apertures of the nostrils, which are not made of flesh and bone, but are cartilaginous, the better to be kept open, as well as to be dilated or contracted, as oc-

casion may require ; for which service they have several curious and proper muscles.

As it is by inspiration, moreover, that the odorous particles are inhaled, and conveyed to the sensory, there is another very wise provision in the laminae with which the upper part of the nose is barricaded, and which serve two excellent purposes; partly to fence out any noxious substances from entering the breathing passages in our sleep, or when not aware of them; and, partly, to receive the divarications of the olfactory nerves. And it is found, that these laminae are always larger, and folded up together in greater numbers, in proportion as the animal has this sense more accurate; their various windings and turnings detaining and fettering a great quantity of the odoriferous particles.

The Taste may be defined to be that sensation which all things, taken into the mouth, give particularly to the tongue, the papillæ of which are the principal instruments thereof. These papillæ are so called from their resemblance to little paps, and, when viewed in the microscope, appear like the pile of velvet. But the greatest writers have differed on this subject. Some consider the palate, the upper part or roof of the mouth, to be the instrument of taste. Of this last opinion is Mr. Locke, who observes, that ‘light and colours come in only by the eyes, all kinds of sounds only by the ears, the several tastes and smells by the nose and palate.’ This opinion is ludicrously alluded to by Prior, in his poem of *Alma* :

By nerves about our palate placed,  
She <sup>1</sup> likewise judges of the taste :  
Else, dismal thought ! our warlike men  
Might drink thick port for fine Champagne.

<sup>1</sup> *Alma*, the Mind.



But whether the organ of taste be seated in the tongue or in the palate, the Divine Wisdom is not less apparent in this sense than in all the others. The judicious Derham observes, that our Creator seems to have established a great consent between the eye, the nose, and tongue, by ordering the branches of the same nerves to each of these three parts, as also, indeed, to various other parts of the body: by which means there is all the guard that can be against pernicious food; since, before it be admitted into the stomach, it is to undergo the trial of three of the senses; the scrutiny of the eye, that strict surveyor of its outward appearance, and the probation of the smell and taste, the two severest judges of its natural constitution and composition.

The Touch, or Feeling, is the fifth sense; by which we acquire the ideas of solid, hard, soft, rough, hot, cold, wet, dry, or other tangible qualities; as also of distance, itching, pain, &c. It is the grossest, but, at the same time, the most exquisite of our senses, having more objects than all the rest taken together; and some even reduce all the other senses to this one of feeling.

The latest and best authors hold the immediate organ of the sense of feeling to be the pyramidal papillæ under the skin. These papillæ are little, soft, medullary, nervous prominences, lodged every where immediately under the cuticle or outermost skin. They are formed of the subcutaneous nerves, which are largest and most conspicuous in those parts chiefly designed for the office of feeling; namely, the tongue, and the tips of the fingers and toes; and they are both contractible and expansive at pleasure. And, therefore, feeling is thus effected: the tip of the finger, for instance, being applied to the object to be examined, by the intention of the mind the papillæ are emitted or elevated, and being slightly rubbed over the surface of the object, a mo-

tion is impressed on them, which being propagated thence by the nerves communicating with them to the common sensory, excites the perception of heat, cold, harshness, or the like.—The nerves are spread in a manner incomparably curious throughout the whole body. But to describe their origin in the brain and spinal marrow, their ramifications to all the parts, their inosculations with one another, &c. by which not only the sense of feeling is performed, but also animal motion, and an admirable consent and harmony between all the parts of the body is effected, more properly belongs to an anatomical account of the nervous system.

Feeling is, on many accounts, the most universal of our senses, no animal being without it; not even those that are generally thought to have no other sense, as oysters and earthworms. Naturalists observe that spiders, flies, and ants have this sense in much greater perfection than man; although we have instances of persons who could distinguish colours by their feeling, and others who could perceive what people said by the same sense. In blind persons the defect of sight has been supplied by an exquisite touch, or sense of feeling, which they have had in such perfection, that, as it has been said of some, they learned to hear with their eyes, it may be said of these, that they taught themselves to see with their hands. A passage, therefore, in Shakspeare's *King Lear*, which has been thought a fine boldness of expression, is extremely natural and pathetic:

O dear son Edgar,  
Might I but live *to see thee in my touch*,  
I'd say, *I had eyes again*.

The dispersion of the sense of feeling throughout the body must not be unnoticed. The other senses, it has been observed, are seated in the very best place for the relief and comfort, the guard and be-

nefit of the animal : and as it was necessary both to the existence and wellbeing of the body, that every part should be sensible of things safe, or things prejudicial to itself, it is, therefore, an admirable contrivance of the great Creator, to disperse this sense of feeling through every part, in order to distinguish between pleasure and pain, and between what is salutary and what is hurtful.

In the account which I have thus given of the five senses, in the present and two preceding papers, it is evident that there is an economy in them worthy of the Creator, and manifestly demonstrative of infinite power, wisdom, and goodness. For, whether we consider the mechanism of the organs, or the great use and convenience of each sense, we find them noble and grand, curious and artificial, every way worthy of an omnipotent hand, and beyond the skill and contrivance of aught but Deity.

The Contemplative Philosopher, then, will never fail to recollect, that what the Deity has thus provided for our use, was provided for the noblest ends. Tully, after expatiating, in his treatise, *De Naturâ Deorum*, on the accurate discernment, and admirable uses of the eye and ear, thus complains : ‘ Our other senses of smelling, tasting, and feeling, are likewise possessed of very acute discernments ; for the gratification and indulgence of which, more arts have been invented than I could wish ; for it is evident to what an extravagant degree the composition of perfumes, the seasoning of meats, and other refinements of sensuality, have been carried.’—Happy the philosopher, happy the man, who disdains the employment of such faculties to the purposes of mere sensual enjoyment. How grateful should he be whose sight enables him to avoid the various perils by which he is surrounded ; to behold the magnificence of the heavens ; the beauties of landscape, and numberless diversities of Creative Power : whose hearing renders

him capable of guarding against every danger that may menace him at a distance; to engage in the sweet intercourses of rational conversation and endearing sentiment; to receive from others the noblest lessons of instruction; and to listen with rapture, to the soothing charms of melody, or to the grander combinations of harmony: who, by his *smell* and *taste*, can distinguish with accuracy, what is salutary from what is unwholesome in his food, and can be susceptible of the pleasing sensations which result from the fragrant beauties of spring, or the lavish bounties of autumn: and, finally, whose *feeling* is so conducive to self-preservation, and productive, in such a variety of respects, of exquisite delight. He will recollect, that our senses, by the ideas which they admit, are the sources of still nobler pleasures—the pleasures of the heart and understanding; which, cultivated with constant assiduity, are so many flowers strewn along the paths that lead to heaven and immortality. For yet a little while, and the *eye* will be no longer charmed with the beauty of terrestrial objects; the *ear* no longer captivated by the enchanting tones of music; the *smell* and *taste* will be insensible to the most fragrant sweets, and the most delicious viands; and the *touch*, now susceptible of such exquisite sensations, will cease alike to affect with pleasure or with pain: in a word, when nothing will remain but the memorial of virtuous fame, and (if fitted for such felicity) a resurrection to the blessedness of the just.

No. XLIX.

ON LIGHTNING AND THUNDER.

Multa tamen restant, et sunt ornanda politis  
Versibus, et ratio cœli, speciesque tenenda:  
Sunt tempestates, et fulmina clara canenda,  
Quid faciant, et quâ de causâ cumque ferantur.

LUCRETIVS.

*Lo, these are parts of his ways! But how little a portion  
is heard of him! But the thunder of his power who can  
understand?*

JOB.

Loud thunder, livid flames, and Stygian night,  
Compounded horrors, all the deep affright.

BLACKMORE.

THE wonders of the Divine Wisdom in our atmosphere are inexhaustible. Of that element itself, with various properties and beneficial uses of it, and some of the most common meteors observable in it, I have already treated. But, as the philosophical poet observes, in my first motto, ‘much still remains to be discussed;’ and, the more we extend our researches, the more shall we be convinced, with the venerable patriarch above, that we know but little in comparison with the secrets of Nature that are yet unknown, and which, by mortals at least, may continue for ever unexplored.

In our atmosphere is observable a variety of meteors; that is, certain changeable, moveable, imperfect mixt bodies, or resemblance of a body, formed of the matter that floats in the atmosphere, and exhibiting various appearances. These meteors<sup>1</sup> are

<sup>1</sup> The Greeks call them *μετεωρα*, that is, *sublimia*, *high-raised*; the Latins *impressiones*, as making signs or impressions in the air.



either aërial, aqueous, or fiery. The aërial meteors consist of flatulent and spirituous exhalations; such as winds, whirlwinds, and hurricanes<sup>1</sup>: the aqueous kind are composed of vapours or watery particles, variously separated, and condensed by heat and cold; such are clouds, rainbows, hail, snow, rain, dew, and the like<sup>2</sup>: and the fiery sort are lightning, aurora borealis, ignis fatuus, draco volans, falling stars, and other fiery phenomena, appearing in the air.—Of these fiery meteors, the lightning, which is among the most formidable phenomena of Nature, shall be the subject of this paper, and the others shall be treated of in a future one<sup>3</sup>.

Agreeably to the method I have adopted, of enlivening my subject with poetical illustrations, whenever it would admit of it, I shall preface the philosophical theory with Thomson's celebrated description of a storm of thunder and lightning:

Behold, slow-settling o'er the lurid grove  
Unusual darkness broods; and growing gains  
The full possession of the sky, surcharged  
With wrathful vapour, from the secret beds,  
Where sleep the mineral generations, drawn.  
Thence nitre, sulphur, and the fiery spume  
Of fat bitumen, steaming on the day,  
With various-tinctured trains of latent flame,  
Pollute the sky, and in yon baleful cloud,  
A reddening gloom, a magazine of fate,  
Ferment; till, by the touch ethereal roused,  
The dash of clouds, or irritating war  
Of fighting winds, while all is calm below,  
They furious spring. A boding silence reigns,  
Dread through the dun expanse; save the dull sound

<sup>1</sup> See No. II, On Winds and Storms.

<sup>2</sup> See No. XLV, On Colours, for the phenomenon of the rainbow; and No. XII for an account of the other aqueous meteors.

<sup>3</sup> See No. LI.

That from the mountain, previous to the storm,  
Rolls o'er the muttering earth, disturbs the flood,  
And shakes the forest-leaf without a breath.  
Prone, to the lowest vale, the ærial tribes  
Deseend : the tempest-loving raven scarce  
Dares wing the dubious dusk. In rueful gaze  
The cattle stand, and on the scowling heavens  
Cast a deploring eye ; by man forsook,  
Who to the crowded cottage hies him fast,  
Or seeks the shelter of the downward cave.

'Tis listening fear and dumb amazement all :  
When to the startled eye the sudden glance  
Appears far south, eruptive through the cloud ;  
And following slower, in explosion vast,  
The thunder raises his tremendous voice.

At first, heard solemn o'er the verge of heaven,  
The tempest growls ; but as it nearer comes,  
And rolls its awful burden on the wind,  
The lightnings flash a larger curve, and more  
The noise astounds : till over head a sheet  
Of livid flame discloses wide ; then shuts,  
And opens wider ; shuts and opens still  
Expansive, wrapping ether in a blaze.

Follows the loosened aggravated roar,  
Enlarging, deepening, mingling ; peal on peal  
Crushed horrible, convulsing heaven and earth.

Down comes a deluge of sonorous hail,  
Or prone-descending rain. Wide-rent, the clouds  
Pour a whole flood ; and yet, its flame unquenched,  
Th' unconquerable lightning struggles through,  
Ragged and fierce, or in red whirling balls,  
And fires the mountains with redoubled rage.  
Black from the stroke, above, the smouldering pine  
Stands a sad shattered trunk ; and, stretched below,  
A lifeless group the blasted cattle lie :

Here the soft flocks, with that same harmless look  
They wore alive, and ruminating still  
In fancy's eye ; and there the frowning bull,  
And ox half-raised. Struck on the castled cliff,  
The venerable tower and spiry fane  
Resign their aged pride. The gloomy woods  
Start at the flash, and from their deep recess,  
Wide flaming out, their trembling inmates shake.  
Amid Caernarvon's mountains rages loud  
The repercussive roar : with mighty crush,  
Into the flashing deep, from the rude rocks

Of Penmaenmaur heaped hideous to the sky,  
Tumble the smitten cliffs; and Snowdon's peak,  
Dissolving, instant yields his wintery load.  
Far-seen, the heights of heathy Cheviot blaze,  
And Thulè bellows through her utmost isles.

And more formidable still is his description of a thunder-storm in the torrid zone:

In blazing height of noon,  
The sun, oppressed, is plunged in thickest gloom.  
Still horror reigns, a dreary twilight round,  
Of struggling night and day malignant mixed.  
For to the hot equator crowding fast,  
Where, highly rarefied, the yielding air  
Admits their stream, incessant vapours roll,  
Amazing clouds on clouds continual heaped!  
Or whirled tempestuous by the gusty wind,  
Or silent borne along, heavy, and slow,  
With the big stores of steaming oceans charged.  
Meantime, amid these upper seas, condensed  
Around the cold aerial mountain's brow,  
And by conflicting winds together dashed,  
The thunder holds his black tremendous throne:  
From cloud to cloud the rending lightnings rage;  
Till, in the furious elemental war  
Dissolved, the whole precipitated mass  
Unbroken floods and solid torrents pours.

Lightning is a large, bright flame, darting swiftly through the air, and extending every way to a considerable distance, of momentary duration, and commonly attended with thunder; that is, with a noise in the lower regions of the air, excited by the sudden explosion of electrical clouds; which, on this account, are called thunder-clouds.

To account for the phenomenon of lightning, some philosophers have supposed, that from the particles of sulphur, nitre, and other combustible matters, which are exhaled from the earth, and carried into the higher regions of the atmosphere, is formed an inflammable substance, which, when a sufficient quantity of fiery particles is separated from the vapour

buoyed up into the air, with these particles adhering to them, by the collision of two clouds or otherwise, takes fire, and shoots into a train of light, larger or less, according to the strength and quantity of the materials. Others have explained lightning by the fermentation of sulphureous substances with nitrous acids.

Had the poet of the Seasons lived at this period, his philosophical theory of lightning would, no doubt, have been greatly modified: for, in the present advanced state of the science of electricity, lightning is universally allowed to be an electrical phenomenon. Philosophers had not proceeded far in their experiments and inquiries on this subject, before they were struck with the obvious analogy between lightning and electricity; and they produced many arguments, *à priori*, to ascertain their similarity. But the method of verifying this hypothesis was first proposed by Dr. Franklin, who, in the year 1749, conceived the practicability of drawing lightning from the clouds. Having found, by previous experiments, that the electric fluid is attracted by points, he apprehended that lightning might likewise possess the same quality; although the effects of the latter must surpass those of the former in an astonishing degree. Flashes of lightning, he likewise observed, are generally seen crooked and waving in the air; and the electric spark drawn from an irregular body at some distance, and when it is drawn by an irregular body, or through a space in which the best conductors are disposed in an irregular manner, always exhibits the same appearance.

Lightning strikes the highest and most pointed objects in its way, in preference to others; as high hills<sup>1</sup>, trees, spires, masts, &c. and all pointed con-

<sup>1</sup> *Feriant summos  
Fulmina montes.* HORACE.

ductors receive and throw off the electric fluid more readily than those which are terminated by flat surfaces. Lightning is observed to take the readiest and best conductor; and this is the case with electricity in the discharge of the Leyden phial<sup>1</sup>; whence Dr. Franklin infers, that, in a thunder-storm, it would be safer for a person to have his clothes wet than dry. Lightning burns, dissolves metals, rends some bodies, strikes people blind, destroys animal life, deprives magnets of their virtue, and reverses their poles; and these are well-known properties of electricity.

Lightning not only gives polarity to the magnetic needle, but to all bodies that have any portion of iron in them, as brick, &c. and, by observing which way the poles of these bodies lie, it may be known, with the utmost certainty, in what direction the stroke passed. Beccaria supposes, that persons are sometimes killed by lightning, without being really touched by it; a vacuum of air only being suddenly made near them, and the air rushing out of their lungs to supply it, and with so much violence that they could never recover their breath. In proof of this he alleges, that the lungs of such persons are found flaccid; whereas, when they are properly killed by the electric shock, the lungs are found inflated: but this hypothesis is controverted by Dr. Priestley.

In order to demonstrate, by actual experiment, the identity of the electric fluid with the matter of lightning, Dr. Franklin contrived to bring lightning from the heavens, by means of an electrical kite, which he raised, when a storm of thunder was perceived to be coming on; and, with the electricity thus obtained, he charged phials, kindled spirits, and

<sup>1</sup> This phial, and other phenomena in electricity, are treated of in No. L.



performed all other electrical experiments, which are usually exhibited by an excited globe or tube. This happened in 1752, a month after the electricians in France, pursuing the method which he had proposed, had verified the same theory; but without any knowledge of what they had done. In 1753, he further discovered, that the air was sometimes electrified positively, and sometimes negatively; and that the clouds would change from positive to negative electricity several times in the course of one thunder-gust. He soon perceived, that this important discovery was capable of being applied to practical use; and he proposed a method, which he soon accomplished, of securing buildings from being damaged by lightning, by means of conductors; the use of which is now universally known.

That the electric matter, which forms and animates the thunder-clouds, issues from places far below the surface of the earth, and that it buries itself there, is probable from the deep holes which have, in many places, been made by lightning; and from the flashes which have been seen to rise from wells and subterraneous cavities; as well as from the inundations accompanying thunder-storms, and occasioned by water bursting out of the bowels of the earth.—But the limits to which I am confined will not permit me to recapitulate all the inquiries and reasonings to which the various wonderful phenomena of lightning and thunder have given rise: I shall therefore proceed to a few observations, which respect the safety of persons that are exposed to the perils of a thunder-storm.

Dr. Franklin advises those who are apprehensive of danger from lightning, to be in the middle of a room (provided it be not under a metal lustre suspended by a chain) sitting on one chair, and laying their feet on another. It is still safer, he says, to

bring two or three mattresses, or beds, into the middle of the room, and folding them double, to place the chairs upon them; for, as they are not such good conductors as the walls, the lightning will not choose to pass through them: but the safest place of all is in a hammock, hung with silken cords, at an equal distance from all the sides of a room. Dr. Priestley observes, that the place of most absolute safety must be the cellar, and especially the middle of it; for when a person is lower than the surface of the earth, the lightning must strike the earth before it can possibly reach him. In the fields, the place of safety is within a few yards of a tree, but not quite near it. Nevertheless, Beccaria cautions persons not to depend on the neighbourhood of a higher, or, in all cases, a better conductor than their own body; since, according to his repeated observations, the lightning by no means descends in one undivided track; but bodies of various kinds conduct their share of it at the same time, in proportion to their quantity and conducting power<sup>1</sup>.

Among the awful phenomena of Nature, none have excited more terror than lightning and thunder. Some of the profligate Roman emperors, of whom history records that they procured themselves to be deified, confessed, by their trembling and hiding themselves, when they heard the thunder, that there was a Divine Power greater than their own—*cælo*

<sup>1</sup> Earl Stanhope, in his *Principles of Electricity*, written when he was lord Mahon, observes, that damage may be done by lightning, not only by the main stroke and lateral explosion, but likewise by that which he calls the returning stroke; that is, by the sudden violent return of that part of the natural share of electricity of any conducting body, or any combination of conducting bodies, which had been gradually expelled from such body or bodies respectively, by the super-induced elastic electrical pressure of a thunder-cloud's electrical atmospheres. See further on this subject, *Franklin's Letters*, *Priestley's Hist. of Electricity*, &c.

*antem Jovem*<sup>1</sup>. The greatest security against the rors of a thunder-storm, although no certain one inst its effects, is that life of piety and virtue ich is the best guardian of every earthly blessing. e good man, who knows that every event is ler the direction of an over-ruling Providence, l that this life is only a part of his existence, in- ductory to the blissful scenes of immortality, will old the terrors of the storm with unshaken reso- on; grateful to the Supreme Being if permitted escape from the danger; and acquiescing in the ine Will, if thus to be conveyed, by an easy and antaneous passage, to that heaven where his con- sation had long been, and to that God with whom delighted to walk.

These sentiments are beautifully expressed in the owing lines, written in a midnight thunder-storm, the celebrated Mrs. Carter, and addressed to a y:

Let coward Guilt with pallid Fear,  
To shelt'ring caverns fly,  
And justly dread the vengeful fate  
That thunders thro' the sky.

Horace. The ancient Romans gave the appellation of *ans*, the Thunderer, to Jupiter, their supreme deity; and emperor Augustus consecrated a temple to Jupiter the mderer, on account of his deliverance from a great danger hich he had been exposed in his Cantabrian expedition; n travelling by night, the vehicle in which he was carried scorched by lightning, and a slave that bore his torch, ntly killed. *Tonanti Jovi ædem consecravit, liberatus culo, cum expeditione Cantabrica per nocturnum iter lec- m ejus fulgor perstrinxisset, servumque prælucentem ex- nasset.* Sueton. Octav. 29. And the poet Lucan adduces thunder as a convincing proof, that Jupiter was the sole r of the skies:

Per fulmina tantum  
et adhuc solum cœlo regnare Tonantem. *Phars. lib. iii.*  
e's thunder will convince them of his reign. ROWE.

Protected by that Hand, whose law  
 The threat'ning storms obey,  
 Intrepid Virtue smiles secure,  
 As in the blaze of day.

In the thick cloud's tremendous gloom,  
 The lightnings lurid glare,  
 It views the same All-gracious Pow'r,  
 That breathes the vernal air.

Thro' Nature's ever-varying scene,  
 By diff'rent ways pursued,  
 The one eternal end of Heav'n  
 Is universal good.

The same unchanging Mercy rules  
 When flaming ether glows,  
 As when it tunes the linnet's voice,  
 Or blushes in the rose.

By Reason taught to scorn those fears  
 That vulgar minds molest;  
 Let no fantastic terrors break  
 My dear Narcissa's rest.

Thy life may all the tend'rest care  
 Of Providence defend;  
 And delegated angels round  
 Their guardian wings extend.

When, thro' creation's vast expanse,  
 The last dread thunders roll,  
 Untune the concord of the spheres,  
 And shake the rising soul;

Unmoved mayst thou the final storm,  
 Of jarring worlds survey,  
 That ushers in the glad serene  
 Of everlasting day.—

Dr. Russell has the following pretty lines  
 dressed to a lady fearful of thunder:

Say, whence this sudden chill, my fair,  
 When thunder rattles thro' the air?  
 Why quits your blood each distant part,  
 And hastes to guard the lab'ring heart?

The flash that strikes the villain dead,  
Is taught to spare the guiltless head ;  
Or should by this the virtuous die,  
'Twere but on lightning's wings to fly,  
And gain with greater speed the sky.

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No. L.

ON ELECTRICITY.

*Causa latet, vis est notissima.*

OVID.

The cause is secret, but th' effect is known.

ADDISON.

THE phenomena of Electricity are so various, so  
lilian, and so remote from the appearances under  
which natural bodies are commonly presented to our  
observation, that while they amuse the superficial,  
they excite the attention of the most incurious ob-  
server, they are adapted to exercise the faculties of  
the most intelligent philosopher, in the investigation  
of their causes and relations. The number and va-  
riety of the experiments which have been made in  
this branch of philosophy, within our own times, is  
astonishing. The scarcity of observations made in  
preceding ages, and even by our immediate pre-  
decessors, on a subject which has proved so fruitful  
to our hands, is almost equally surprising. From  
the time of Thales the Milesian, who flourished  
about 640 years before Christ, and Theophrastus,  
disciple of Aristotle, who lived about 300 years  
after, down to the middle of the seventeenth century,  
that had been said, or that was known of elec-  
tricity, might be contained within the compass of a  
paper. Even the more modern writers of general



systems of natural philosophy either neglected it, or thrust the little which they had to say concerning it into some obscure corner of their work, and under other articles; not deeming it of sufficient importance to give it a separate place. Since the year 1720, however, various interesting and important phenomena have been observed; and these have given rise to a variety of reasonings and theories. The extensiveness, moreover, of this branch of knowledge, with regard to the relation which it now bears to many of the other sciences, is not less worthy of observation. Down to the times even of Boyle and Newton, electricity has been solely employed in attracting and repelling straws and chaff: in our days it has extended its influence even into the atmospheric regions, and has formed connexions with almost every branch of natural philosophy. It has even soared so high as to court an alliance with physical astronomy, and has had the confidence even to put in a claim, which may perhaps one day be allowed, of having a share in the production of some of the grandest phenomena of Nature.

The term *electricity* is derived from *ηλεκτρον*, the Greek name for *amber*; a yellow transparent substance which has been very anciently observed to possess, when rubbed, the property of attracting light bodies; insomuch that Thales of Miletus concluded hence, that it was animated<sup>1</sup>. The term *electricity* is now applied, not only to the power of attracting light bodies inherent in amber, but to other similar powers, and their various effects, in whatever bodies they reside, or to whatever bodies they may be communicated.—In a word, by *electricity* or *electrical force*, is understood, not only that

<sup>1</sup> Amber is also brought, by friction, to yield light pretty copiously in the dark; and hence it is reckoned among the native *phosphori*.

power or property, which the ancients observed in amber and the lyncurius lapis, or tourmalin, but which agate, jet, sealing-wax, glass, and a variety of other substances, called *electrics*<sup>1</sup>, are now known to possess, of attracting light bodies, &c. when excited by heat or friction; and which is also capable of being communicated, in particular circumstances, to other bodies: and the science of electricity is that part of natural philosophy, which proposes to investigate the nature and effects of this power, and of other similar powers connected with it.

Thus we find, that electricity was indebted to the ancients for little more than its name, which it still retains, and which, although very inadequate to the present state of this branch of knowledge, was sufficiently expressive of the little which they knew concerning it. The father of modern electricity appears to have been Dr. Gilbert, author of an excellent treatise, *De Magnete*, published in 1600, who greatly augmented the list of electrical bodies. This was increased about a century afterward, by Mr. Boyle, who observed some new circumstances concerning electrical attraction. His contemporary, Otto Guericke, the celebrated inventor of the air-pump, first took notice of the mutual repulsion of

<sup>1</sup> *Electrics* are those substances, in which the electric fluid is capable of being excited, and accumulated, without transmitting it, and therefore called *non-conductors*, in opposition to *conductors*, which are called *non-electrics*. The *electrics* are likewise called *electrics per se*, and *original electrics*. They are capable of being excited, so as to exhibit the electrical appearances of attracting and repelling light bodies, emitting a spark of light, attended by a snapping noise, and yielding a current of air, the sensation of which resembles that of a spider's web drawn over the face, and a smell like that of phosphorus, either by friction, or by heating and cooling, or by melting, and pouring one melted substance into another. *Conductors* denote those substances, which are capable of receiving and transmitting the electric virtue. These terms were first introduced by Dr. Desaguliers.

bodies electrified, and of the light and sound exhibited by excited electrics. The illustrious Newton was content with a few experiments, from which it appeared, that excited glass attracted light bodies on the side opposite to that on which it was rubbed. In 1709, Mr. Hawksbee, by means of his glass globes, as well as those of sealing-wax and resin, observed many new and striking phenomena. Mr. Grey, about twenty years after, first discovered, that the electric virtue might be communicated from excited electrics to non-electrics in contact with them. To him, likewise, and to his friend Mr. Wheeler, we are indebted for the important discovery of insulating bodies, by which the electricity communicated to them is detained and preserved, and which laid the foundation of almost all the subsequent discoveries. M. du Fay next made a capital discovery; that of the two species of electricity, which he denominated the vitreous and resinous, from the principal substances to which they respectively belong: the characteristic of which two kinds is, that bodies, possessed of one of them, repel all other bodies, whose electricity is of the same species with their own, and attract all bodies possessed of the other species. M. du Fay also, accompanied by abbé Nollet, first perceived the electric spark; and the abbé declares that he shall never forget the surprise excited both in M. du Fay and himself, by the first electrical spark that was ever drawn from the human body. In Mr. Grey's experiments, subsequent to this, we find the origin of metallic insulated conductors, and the first observation of the pencil of rays perceived at their pointed extremities.

Electricity, however, did not make any rapid progress till after the year 1743, when the use of globes was again introduced by the German philosophers; tubes only, after the time of Hawksbee, being made use of in electrical experiments. By the size and

number of their globes, the Germans excited a prodigious power of electricity. The strength of the simple electric sparks was increased to such a degree, that they were felt from a man's head to his foot, and small birds were killed by them. But the most surprising effect produced by the German machines, was the accession of inflammable bodies by the electric spark, in 1744, by Dr. Ludolf of Berlin, who kindled, by its means, the vitriolic ether. Dr. Watson, in England, about this period, fired spirits considerably diluted, distilled vegetable oils, resinous substances, and gunpowder. He set fire to the factitious air produced by the solution of iron in diluted spirit of vitriol, which when it did not find a ready passage out of the mouth of the flask in which it was contained, was kindled throughout its whole capacity, with an explosion equal to that of a large pistol. He likewise fired spirit of wine by a drop of cold water, and afterward even by ice.

But the most amazing of all the electrical discoveries was the Leyden phial, so called from the place in which it was made, in 1746, by Mr. Cuneus, as he was repeating some experiments of messieurs Muschenbroeck and Allamand; or, as others say, by Mr. Muschenbroeck himself, who first felt the shock as he was using an iron cannon, suspended on silk lines, for a conductor. Dr. Priestley, in his *History of Electricity*, gives an account of the descriptions which those who first felt the electric shock gave of it, while they were under the influence of the panic it occasioned. 'Mr. Muschenbroeck (says he) who tried the experiment with a very thin glass bowl, says, in a letter to M. Reaumur, which he wrote soon after the experiment, that he felt himself struck in his arms, shoulders, and breast, so that he lost his breath, and was two days before he recovered from the effects of the blow and the terror. He adds, that he would not take a se-



cond shock for the kingdom of France.'—Other electricians have described the same terrors; and their descriptions, in the present advanced state of electricity, may appear exaggerated. But we may, in some measure, account for this, by considering that they were under the influence of the surprise and terror excited by a *new* and *unexpected* feeling, of a very peculiar kind, produced by a seemingly inadequate cause, lurking in a tumbler of water. The sensation caused by the electric shock is, indeed, a perfect *unique*; and every change or commotion perceived in the body for some time after the shock thus circumstanced, might be attributed naturally enough, by a timorous person, although ever so well acquainted with the phenomena of electricity already known, or the laws already established, to some secret and unaccountable operations of this invisible and mysterious agent; part of which, on this new and strange modification of it, might be suspected, on its dislodgment from the tumbler, to have only changed its quarters, and to be still lying in ambush, and playing its pranks with the body; or, at least, to have *permanently* discomposed and ruffled some of the fibres, in its rapid passage through it. Even at this day, the marvellous air of this experiment is not so far diminished by frequent repetitions, but that it still throws a similar delusion on many; who are thereby induced to think that they feel the effects of the electric shock for some time after it has been given; and few receive it without some degree of perturbation.—It was this astonishing experiment, Dr. Priestley observes, that gave an eclat to electricity. Every body was eager to see, and, notwithstanding the terrible account that was reported of it, to feel the sensation produced by it. It is to this day justly viewed with astonishment by the most profound electricians: for though some remarkable phenomena of it have been excellently accounted for



by Dr. Franklin, Cavallo, Cavendish, and others, still much remains to be done, and, in many respects, the circumstances attending it are still inexplicable.

In 1747, Dr. Watson made a variety of noble experiments, with a view of ascertaining the distance to which the electric shock could be carried, and the velocity with which it moves. In the first of these, the shock was given, and spirits kindled, by electric fire which had been conveyed through the Thames. In a subsequent experiment, the sensible instantaneity of the motion of the electric fluid was directly ascertained by an observer, who, though in the same room with the charged phial, was at the same time in the middle of an electric circuit of two miles, and *felt* himself shocked, at the same instant that he *saw* the phial discharged. Another important discovery by Dr. Watson was, that the glass globes and tubes did not contain within themselves the electric fluid which appeared on their excitation, but drew it from the earth and the bodies contiguous to the rubber, and in contact with it. Mr. Wilson appears to have made the same observation. Dr. Watson likewise discovered, what Dr. Franklin had observed about the same time in America, the *plus* and *minus* states of electrified bodies.

This simple principle of the *plus* and *minus*, or the *positive* and *negative* states of the electric matter in bodies, became, in the hands of Dr. Franklin, as fruitful (if we make allowance for the different nature and importance of the subject) as the principle of universal attraction in those of Newton. By the application of it, the Leyden phial, which had hitherto teemed with mystery and contradiction, had its most glaring inconsistencies reconciled and accounted for in the most simple manner. The doctor showed, that in the act of electrization, one side of the phial (the inside, for instance) was electrified *positively*; that is, had an additional quantity

of the electric fluid thrown upon it; and that the other side was electrified *negatively*; that is, was deprived of an equal quantity; and that the effect of that operation was not an increase of the quantity of electric fire in the phial, but solely a change produced in the situation of the *natural quantity* of electric matter belonging to it.

Dr. Franklin's important discovery of the identity of lightning, and the electric fire, I mentioned in my last paper. This is one of the few capital discoveries in electricity, for which we are not at all indebted to chance, but to one of those bold and happy stretches of thought, in consequence of which those gigantic strides are made in science, which distinguish geniuses of a superior order. By this interesting and important discovery (the greatest, perhaps, that has been made in the whole compass of philosophy since the time of Sir Isaac Newton) we have it now in our power, by a simple and cheap apparatus, to direct the course of the hitherto *inevitable fulmen*, and thereby, with respect to buildings at least, to deprive it of its power of hurting. By what simple and slender instruments, even the playthings of children, does the hand of Genius extort from Nature her choicest secrets. Thus Newton, by means of a soap-bubble, investigates the magnitude of the component particles of bodies, on which their colour depends; and Franklin, by raising a kite, discovers the nature of lightning!

The last great discovery of which I shall take notice (and to which Mr. Canton led the way) is that of a new and very extensive principle in electricity, by messieurs Wilke and *Æpinus*, two foreign electricians. The principle, which, indeed, is founded on Dr. Franklin's theory of positive and negative electricity, is this; that the electric fluid, when there is a redundancy of it in any body, repels the electric fluid in any other body, within its influence, and

drives it into the remote parts, or quite out of the body, if there be any outlet for that purpose; thereby reducing the body to a state contrary to its own; that is, a negative state. On this principle they undertook to charge a *plate of air*, like a plate of glass, and thereby to imitate, in the most perfect manner, the phenomenon of lightning. They succeeded, by suspending two large boards of wood covered with tin, with the flat sides parallel to one another, and some inches asunder. On electrifying *positively* one of the boards (which may be considered as metallic coatings to the two surfaces of the *aërial plate*) the other board became electrified *negatively*; and a person, touching this last with one hand, and bringing his other to the other board, received a shock through his body, as in the Leyden experiment.—With this plate of air they made a variety of curious experiments. The two metal plates being in opposite states, strongly attracted each other, and would have rushed together, if they had not been kept asunder by strings. Sometimes, the electricity of both would be discharged by a strong spark between them, as when a plate of glass bursts, and is perforated by too great a charge: A finger put between them promoted the discharge and felt the shock. If an eminence were made on either of the plates, the self-discharge would always be made through it; and a pointed body fixed upon either of them prevented their being charged at all.

The state of these two plates, they excellently observed, justly represents the state of the clouds during a thunder-storm; the clouds being always in one state and the earth in the opposite; while the body of air between them answers the same purpose as the small plate of air between the boards, or the plate of glass between the two metal coatings of the Leyden phial. The phenomenon of lightning is the bursting of the plate of air by a spontaneous discharge, which

is always made through eminences, and the bodies through which the discharge is made are violently shocked.

With respect to the nature of the electric fluid, philosophers have entertained very different sentiments. Mr. Wilson, and others, have supposed it to be the same with the ether of sir Isaac Newton; but Dr. Priestley is of opinion, that the electric matter is either phlogiston, or contains it. Some again regard the phenomena of electricity, as occasioned by two distinct fluids, both elastic, but endowed with opposite properties with respect to electricity.—But it cannot be expected, in the contracted space to which I am confined, that I can enlarge further on this science; a science on which so many volumes have been written. I have been obliged to treat the subject in a general light; as exhibiting a matter of curious speculation, to observe the ignorance of the greatest men, for so many ages, concerning phenomena, with which no man of letters is now entirely unacquainted. It is no less entertaining and instructive to observe, that even after some light had been thrown upon the subject, it required the efforts of ingenious men, for near a century more, to bring the science to its present advanced state; that, however, so far from having reached perfection, the mysteries of Nature are so profound, that there are still many desiderata to be known, sufficient to perplex the most intelligent philosopher, and to induce him to suspect, while he looks back with the exultation of superiority, at the ignorance of the ancients, and even of the illustrious sages of the seventeenth century, with respect to the present most obvious principles of the science, that we may appear like children to the philosophers of another age, whom new phenomena, new principles, and perhaps a new theory, may astonish; while, impressed with a more awful and religious sense of the wonderful

operations of the Deity, they may exclaim in the language of the celestial choir, '*Hallelujah, for the Lord God Omnipotent reigneth.*'

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Since the original publication of this work, the department of electricity has received a great accession by the discovery of *Galvanism*, or *Voltaism*, which embraces the phenomena that result from different conductors of electricity being placed under different circumstances of contact.

The conductors must be either perfect, or imperfect conductors of electricity; and the galvanic phenomena may be produced by two conductors of one of these classes placed in contact with each other, in one or more points, and in other distinct points with a conductor of the other class: thus gold and zinc may be made to touch each other in some points, and may be connected, in other points, by a portion of common water. To produce the galvanic phenomena with any considerable effect, several series of conductors, thus disposed, should be employed. Then may an acid taste, a flash of light, the contractions of muscles recently detached from a living body, the oxidizement of metals, and the decomposition of acids and of water be produced. Shocks, also, on the human body analogous to the electric shock, and brilliant sparks, with the deflagration of even silver and gold, may be occasioned by this fluid, under certain circumstances.

*Galvani* discovered in 1791 the contraction of muscles by means of this fluid. But *Volta*, in 1793, added greatly to the stock of facts, and connected them by a theory, which has since been denominated *Voltaism*. This philosopher also discovered the method of accumulating the effects of this species of electricity, now known by the name of the Voltaic pile. The late Mr. Nicholson was, we believe, the



first who ascertained the chemical action of galvanism, and its power of decomposing water. Sir Humphry Davy has, also, been very successful in extending this branch of human knowledge. For his important discoveries in reference to this point, the reader will do well to consult Mr. Parkes's Chemical Catechism, or Henry's System of Chemistry.

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No. LI.

ON THE AURORA BOREALIS, AND OTHER  
FIERY METEORS.

Silent from the north

A blaze of meteors shoots : ensweeping first  
The lower skies, they all at once converge  
High to the crown of heaven, and all at once,  
Relapsing quick, as quickly reascend,  
And mix, and thwart, extinguish, and renew,  
All ether coursing in a maze of light.      THOMSON.

THE Aurora Borealis, or Northern Lights, is a kind of meteor appearing in the northern part of the heavens, mostly in the winter time, and in frosty weather. It is now so generally known, that no description is requisite of the appearance which it usually makes in this country. But it is in the arctic regions that it appears to perfection, particularly during the solstice. In England, the extremities only of these northern lights are to be seen, that we have but a faint idea of their splendour and their motions<sup>1</sup>. According to the state of the atmosphere,

<sup>1</sup> Of the Aurora Borealis in Shetland, Siberia, and Hud-

they differ in colours. They often assume the colour of blood, and make a very dreadful appearance. The rustic sages become prophetic, and terrify the gazing spectators with a dread of war, pestilence, and famine. This superstition was not peculiar to the northern islands; nor are these appearances of recent date. The ancients called them *chasmata*, *rubes*, and *bolides*, according to their forms or colours. But, in old times, they were extremely rare, and, on that account, were the more taken notice of. From the days of Plutarch to those of our sage historian Sir Richard Baker, they were supposed to be portentous of great events, and timid imaginations shaped them into aerial conflicts:

From look to look, contagious through the crowd,  
The panic runs, and into wondrous shapes  
Th' appearance throws: Armies in meet array,  
Thronged with aerial spears and steeds of fire;  
Till the long lines of full-extended war  
In bleeding fight commixt, the sanguine flood  
Rolls a broad slaughter o'er the plains of heaven.  
As thus they scan the visionary scene,  
On all sides swells the superstitious din,  
Incontinent; and busy Frenzy talks  
Of blood and battle; cities overturned,  
And late at night in swallowing earthquake sunk,  
Or hideous wrapt in fierce ascending flame;  
Of sallow famine, inundation, storm;  
Of pestilence, and every great distress;  
Empires subversed, when ruling Fate has struck

on's Bay, and its beneficial effects in the polar regions in general, see No. v, On Winter in the Polar Regions.

By dancing meteors then, that ceaseless shake  
A waving blaze refracted o'er the heavens,  
And vivid moons, and stars that keener play  
With double lustre from the glossy waste,  
Ev'n in the depth of polar night, they find  
A wondrous day: enough to light the chase,  
Or guide their daring steps to Finland-fairs. THOMSON.

Th' unalterable hour : ev'n Nature's self  
Is deemed to totter on the brink of time.  
Not so the man of philosophic eye,  
And inspect sage ; the waving brightness he  
Curious surveys, inquisitive to know  
The causes, and materials, yet unfixed,  
Of this appearance beautiful and new.

THOMSON.

The earliest distinct history of this phenomenon, is what we have from the learned Dr. Halley, in the *Philosophical Transactions*, No. 347. The first account he gives, is of the appearance of what the author calls *burning spears*, and which was seen at London in 1560. This account is taken from a book entitled, *A Description of Meteors*, by W. F. D. D. and reprinted at London in 1654. The next appearance, on the testimony of Stow, was in October 1564. In 1574 also, according to Camden and Stow, an *aurora borealis* was observed two nights successively. Two were seen, at different times, in the year following, in Brabant. They were compared, by Cornelius Gemma, to spears, fortified cities, and armies fighting in the air. Michael Mæstlin, tutor to the great Kepler, assures us, that, in the county of Wurtemberg in Germany, these phenomena, which he calls *chasmata*, were seen by himself, no less than seven times, in 1580. In 1581, they appeared in an extraordinary manner in April and September, and in a less degree at some other times of the same year. In September 1621, this phenomenon was observed all over France, and described by Gassendus, who gave it the name of *aurora borealis* ; yet neither this, nor any similar appearances posterior to 1574, are described by English writers till the year 1707 ; which, as Dr. Halley observes, shows the great neglect of curious matters which at that time prevailed. From 1621, indeed, to 1707, there is no mention of an *aurora borealis* having been seen by any person, either in

England or foreign countries; and, considering the number of astronomers, who, during that period, were almost constantly observing the heavens, we may reasonably conclude, that no such phenomenon appeared till after an interval of eighty-six years. In 1707, a small one was seen in November; and during that year and the next, the same appearances were repeated five times. The next on record is that mentioned by Dr. Halley, as appearing on March 6, 1716. The splendour of this attracted universal attention. By the vulgar it was viewed with consternation; and they considered it as marking the introduction of a foreign race of princes into this country<sup>1</sup>. Since that time, these meteors have been so common, that no account has been kept of them.

It was for a long time a doubt whether this meteor appeared only in the northern hemisphere, or whether it were to be observed also near the south pole. This is now ascertained by Mr. Forster, who, in his Voyage round the World with captain Cook, assures us, that he observed it in the high southern latitudes, although with appearances somewhat different from those which are seen here. ‘On the 17th of February 1773 (says Mr. Forster) as we were in latitude  $58^{\circ}$  south, a beautiful phenomenon was observed during the preceding night, which appeared again several following nights. It consisted of long columns of a clear white light, shooting up from the horizon to the eastward, almost to the ze-

<sup>1</sup> Dr. Halley observed, that this aurora borealis rose to a prodigious height, it being seen from the west of Ireland to the confines of Russia and Poland on the east; nor did he know how much farther it might be visible; so that it extended at least  $30^{\circ}$  in longitude, and from latitude  $50^{\circ}$  north it was seen over all the northern parts of Europe; and, in all the places where it was visible, the same appearances were exhibited, which Dr. Halley observed in London.



nith, and gradually spreading on the whole southern part of the sky. These columns were sometimes bent sidewise at their upper extremities; and, although in most respects similar to the northern lights of our hemisphere, yet differed from them in being always of a whitish colour; whereas ours assume various tints, especially those of a fiery and purple hue. The sky was generally clear when they appeared, and the air sharp and cold, the thermometer standing at the freezing point.\*

I shall not attempt to give any account of the earlier conjectures concerning the cause of this phenomenon. It will be sufficient to observe, that ever since the identity of lightning, and of the electric matter, has been ascertained, philosophers have been naturally led to seek the explication of aërial meteors in the principles of electricity; and there is now no doubt, but that the greater part of them, and especially the aurora borealis, are electrical phenomena. Beside the more obvious and known appearances which constitute a resemblance between this meteor and the electric matter by which lightning is produced, it has been observed, that the aurora borealis produces a very sensible fluctuation in the magnetic needle; and that, when it has extended lower than usual into the atmosphere, the flashes have been attended with various sounds of rumbling and hissing, taken notice of both by Beccaria and M. Messier. But I have, in some measure, anticipated this part of my subject, in my paper *On Comets*<sup>1</sup>, to which I refer my readers for the sentiments of Dr. Hamilton and abbé Mann, who have each produced the most satisfactory arguments to demonstrate the identity of the matter that forms the tail of comets, the aurora borealis, and the electric fluid. Dr. Blagden has also given a copious illustration of

<sup>1</sup> No. VIII.



this subject in his account of some fiery meteors, which appeared in 1783<sup>1</sup>.

Of the aurora borealis I have one more observation to make of great importance to seamen. In 1772, Mr. Winn presented a paper to the Royal Society, in which he says, that the appearance of an aurora borealis is a certain sign of a hard gale of wind from the south or southwest. This he never found to fail in twenty-three instances; and he even thinks, that from the splendour of the meteor, some judgment may be formed concerning the ensuing tempest. If the aurora be very bright, the gale will come on within twenty-four hours, but will be of no long duration: if the light be faint and dull, the gale will be less violent, and longer in coming on, but will also last longer. His observations were made in the English Channel, where such winds are very dangerous; and, by attending to the aurora, he says he often got easily out of it, when others narrowly escaped being wrecked<sup>2</sup>.

There are other fiery meteors beside lightning and aurora borealis; such as *fiery globes*, moving at prodigious heights, with incredible velocity<sup>3</sup>; the *ignis fatuus*, *draco volans*, *falling stars*, &c.

The Ignis Fatuus is a common meteor, chiefly seen in dark nights, frequenting meadows, marshes, and other moist places, and often seen in burying-grounds, and near dunghills. It is known among the common people by the name of Will with a Wisp, and Jack with a Lanthorn. The form and size of these *ignes fatui* are very various. The late

<sup>1</sup> Phil. Trans. vol. lxxiv. part i.

<sup>2</sup> Phil. Trans. vol. lxiv. part i. For M. Libes's new theory of the aurora borealis, see Gregory's translation of Haüy's Natural Philosophy, or the new edition of Dr. Hutton's Mathematical Dictionary.

<sup>3</sup> For a description of these fiery globes, I must refer to Dr. Blagden's account above-mentioned.

And plaintive children his return await,  
 In wild conjecture lost. At other times,  
 Sent by the *better Genius* of the night,  
 Innocuous, gleaming on the horse's mane,  
 The meteor sits ; and shows the narrow path,  
 That winding leads through pits of death, or else  
 Instructs him how to take the dangerous ford.

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No. LII.

ON MAGNETISM AND THE MARINER'S  
 COMPASS.

Almighty Cause ! 'tis thy preserving care,  
 That keeps thy works for ever fresh and fair :  
 Hence life acknowledges its Glorious Cause,  
 And matter owns its Great Disposer's laws ;  
 Hence flow the forms and properties of things ;  
 Hence rises harmony, and order springs.  
 Thy watchful providence o'er all intends ;  
 Thy works obey their Great Creator's ends.  
 Thee, Infinite ! what finite can explore ?  
 Imagination sinks beneath thy power.  
 Yet present to all sense that power remains :  
 Revealed in Nature, Nature's Author reigns.

BOYSE.

ALTHOUGH the phenomena of the magnet have, for many ages, engaged the attention of natural philosophers, not only by their singularity and importance, but also by the obscurity in which they are involved ; yet very few additions have been made to the discoveries of the first inquirers into the subject. The powers of genius which have been hitherto employed in investigating this subject, have not been able to frame a hypothesis, that will account, in an easy and satisfactory manner, for all

the various properties of the magnet, or to point out the links of the chain which connect it with the other phenomena of the universe. It is certain, indeed, that both natural and artificial electricity will give polarity, or a direction to the poles of the earth, to needles, and even reverse a given polarity; and hence it may be inferred, that there is a considerable affinity between the electric and magnetic fluid; but in what manner electricity acts in producing magnetism, is still utterly unknown.

From the works of Hippocrates, Plato, and Aristotle, who each flourished above three centuries before the christian era, it is certain that the ancients were acquainted with the attractive and repulsive powers of the magnet; but it does not appear, that they knew of its tendency to the pole, or of the mariner's compass. Lucretius, in his sixth book *De Rerum Naturâ*, has given a poetical dissertation upon the attractive property of the magnet, but without the least intimation of its polarity. To him, however, we are indebted for the origin of the term *magnet*:

Quod superest, agere incipiam, quo fœdere fiat  
Naturæ, lapis hic ut ferrum ducere possit.  
Quem magneta vocant patrio nomine Graii,  
Magnesium quia sit patriis in finibus ortus.

That is, 'The magnet, of whose attractive virtues he intends to treat, is so called, by the Greeks, from *Magnesia*, a district of *Lydia*, in which it was first found.' Aristotle, by way of excellence, calls it only *λίθος*, *the stone*. Pliny calls it *Heraclius lapis*, from the city of *Heraclea*, in the country of the *Magnetes* abovementioned. By the Italians it is called *calamita*, and by the French *aimant*. Our English name, the *loadstone*, is of Saxon extraction.

As the ancients were not acquainted with the true method of philosophising, and were content with ob-

servation alone, their knowledge of nature was very confined, and did not afford any considerable advantage to society. Modern philosophers, by combining experiment with observation, soon extended the boundaries of science, and discovered the polarity of the magnet; a property which constitutes the basis of navigation, and greatly facilitates commerce.

The loadstone, leading stone, or natural magnet, is a ferruginous stone, found in the bowels of the earth, generally in iron mines; of all forms and sizes, and of various colours. It is endowed with the property of attracting iron; and of both pointing itself, and also enabling a needle, touched upon it, and duly poised, to point toward the poles of the world.—Loadstones, in general, are very hard and brittle; and, for the most part, more vigorous, in proportion to their degree of hardness. Considerable portions of iron may be extracted from them. Mr. Kirwan says, that the magnet seems to contain a small quantity of sulphur, and is often contaminated with a mixture of quartz and argil. It is possible, it may contain nickel; for this, when purified to a certain degree, acquires the properties of a magnet; but its constitution has not hitherto been properly examined<sup>1</sup>.

Artificial magnets, which are made of steel, are now generally used in preference to the natural magnet; not only, as they may be procured with greater ease, but because they are far superior to the natural magnet in strength, communicate the magnetic virtue more powerfully, and may be varied in their form more easily. The natural magnet, in course, is now very little esteemed, except as a curiosity.

The power of attracting iron, &c. possessed by

<sup>1</sup> Kirwan's Elements of Mineralogy, p. 271.

stone, which is also communicable to iron or steel, is called *magnetism*. A rod or bar, of steel, to which a permanent polarity has been communicated, is called a *magnet*. The points of a magnet which seem to possess the greatest virtue, or in which the virtue seems to be concentrated, are termed the *poles of a magnet*. The *magnetic meridian* is a vertical circle in the heavens which intersects the horizon, in the points to which the magnetical needle, when at rest, is directed. Its *axis* is a right line which passes from one pole to the other; and its *equator* is a line perpendicular to the axis of the magnet, and exactly between the two poles.

The distinguishing and characteristic properties of a magnet are, first, its attractive and repulsive powers; secondly, the force by which it places itself when suspended freely, in a certain direction with respect to the poles of the earth; thirdly, its dip or inclination toward a point below the horizon; and, fourthly, the property it possesses of communicating its magnetic powers to iron or steel.

It has been already observed, that the ancients do not appear to have been acquainted with the directive power of the magnet. Philosophers were content, for many ages, with the knowledge of its attractive and repulsive qualities. But, about the beginning of the fourteenth century, when the spirit of exploring distant regions was gradually forming in Europe, a very fortunate discovery was made, which excited more than all the ingenuity and efforts of succeeding ages, to improve and to extend navigation. That wonderful property of the magnet, by which it communicates such virtue to a needle, or rod of iron, as to point towards the poles of the earth, was then first observed. The use which has been made of this in directing navigation was immediately perceived. That most valuable, but



now familiar instrument, the Mariner's Compass, was invented. When navigators found, that by this instrument, they could, at all seasons, and in every place discover the north and south with the greatest ease and accuracy, it became no longer necessary to depend, like the voyagers of former ages<sup>1</sup>, merely on the light of the stars, and the observation of the seacoast. They gradually abandoned their ancient timid and lingering course along the shore, ventured boldly into the ocean, and, relying on this new guide, could steer in the darkest night, and under the most cloudy sky, with a security and precision till then unknown. The compass may be said to have opened to man the dominion of the sea, and to have put him in full possession of the earth, by enabling him to visit every part of it. Flavio Gioia, a citizen of Amalsi, a town of considerable trade in the kingdom of Naples, was the author of this discovery, about the year 1302. It has been often the fate of those illustrious benefactors of mankind, who have enriched science, and improved the arts, by their inventions, to derive more reputation than benefit from the happy efforts of their genius. But the lot of Gioia has been still more cruel: through the inattention or ignorance of contemporary historians, he has been defrauded even of the fame to which he had so just a title. We receive no information from them respecting his profession, his character, the precise time when he made this important discovery, or the accidents and inquiries which led to it. The knowledge of this discovery, though productive of greater effects than any recorded in the annals of the human race, is transmitted to us without any of those circumstances, which can gratify the curiosity it must naturally awaken<sup>2</sup>.

<sup>1</sup> See No. LVI, On the Art of Navigation.

<sup>2</sup> In this account of the discovery of the mariner's compass,

But although the use of the compass might enable the Italians to perform the short voyages to which they were accustomed, with greater security and expedition, its influence was not so sudden or extensive, as immediately to render navigation adventurous, and to excite a spirit of discovery. Many causes combined to prevent this beneficial invention from producing its full effect immediately. Men relinquish ancient habits slowly and reluctantly: they are averse to new experiments, and venture upon them with timidity. The commercial jealousy of the Italians, it is probable, laboured to conceal the happy discovery of their countryman from other nations. The art of steering by the compass with such skill and accuracy as to inspire a full confidence in its direction, was acquired progressively. Sailors, unaccustomed to lose sight of land, durst not launch out at once, and commit themselves to unknown seas. Accordingly, near half a century elapsed, from the time of Gioia's discovery, before navigators ventured into any seas which they had not been accus-

I have adhered to the opinion of Dr. Robertson, who, in his *History of America*, vol. i. quotes, as his authority, *Collinas et Trombellas de Acus Nauticæ Inventore. Instit. Acad. Bonon.* tom. ii.—It may not be improper, however, to observe, that this great discovery has been referred to an earlier period. Marco Polo, a noble Venetian, and great traveller, is said to have introduced the compass in 1260; but this is likewise said not to have been his own invention, but borrowed from the Chinese: while others assert, that the Chinese knew nothing of the mariner's compass, till it was introduced into their country by the Europeans. See *Chambers's Cyclopædia*, and *Adams on Electricity*.—M. Perrault, in his *Parallel between the Ancients and the Moderns*, has cited some verses of Guyot, of Provence, who wrote about the year 1180, from which one might be led to infer, that the use of the compass was then known in the south of France: 'There is (says he) a star that never moves, and an art that never deceives, by the virtue of the compass, an ugly black stone, which always attracts iron.'

tomed to frequent. But, in the course of the  
teenth century, discoveries were made far bey  
the conception of all former ages. It is worth  
note, however, that there is a passage in the M  
of Seneca, to which these very discoveries migh  
most seem to give the importance of a predictio

Venient annis  
Secula seris, quibus oceanus  
Vincula rerum laxet, et ingens  
Pateat tellus, Tiphysque novos  
Detegat orbes.

In ages yet to come,  
Another Tiphys may new seas explore,  
And worlds discover never known before.

It is remarkable, that in the first voyage of  
lumbus, in the year 1492, when his little fleet  
above 200 leagues to the west of the Canary I  
the Spaniards were struck with an appearance no  
astonishing than new. They observed that the m  
netic needle, in their compasses, did not point ex  
to the polar star, but varied toward the west ;  
as they proceeded, this variation increased.  
appearance, which is now familiar, although it  
remains one of the mysteries of nature, into the c  
of which the sagacity of man has not yet been  
to penetrate, filled the companions of Colum  
with terror. They were then in a boundless  
known ocean, far from the usual course of na  
tion: nature itself seemed to be altered ; and  
only guide which they had left seemed about to  
them. Columbus, with equal quickness and i  
nuity, invented a reason for this appearance, wh  
although it did not satisfy himself, seemed so p  
sible to them, that it dispelled their fears<sup>1</sup>.

<sup>1</sup> Robertson's History of America.



This appearance, so alarming to the Spaniards, is that deviation from the meridian which is called the *variation of the needle*, and is different in different parts of the world; being west at some places, east at others, and in parts where the variation is of the same name its quality is very different. Sebastian Cabot is generally allowed to be the first, who, about the year 1497, more accurately ascertained the reality of this variation, and that it was the same to all needles in the same place. For a long time after, it was thought to be invariably the same, at the same place in all ages; but Mr. Gellibrand, about the year 1625, discovered that it was different at different times in the same place. From subsequent observations, it appears, that this deviation was not a constant quantity, but that it gradually diminished; and, at last, about the year 1660, it was found that the needle pointed due north at London, and has ever since been increasing to the westward of the north. It appears, therefore, that in any one place, the variations have a kind of libratory motion, traversing through the north to certain limits eastward and westward<sup>1</sup>: and indeed vacillating a little daily.

To return to the magnet, it has been observed, that no substance interposed between it and iron, can prevent the action of its attractive energy. All metals (iron excepted) wood, glass, fire, water, and even men and animals, afford a free passage to its influence. It has been observed, moreover, that of two magnets the north pole of the one attracts the south pole of the other, and repels its north pole; while, on the contrary, the north pole of the second was attracted by the south pole of the first, which repelled constantly the south pole of the second. The

<sup>1</sup> See Adams on Electricity; and for an ample account of the Theories of the Variation of the Compass, see the Treatise on Magnetism in Haüy's Natural Philosophy.

attractive tendency in iron and a magnet is also reciprocal ; and they are often attached to each other with such force as to require a considerable weight to separate them.

Among the various hypotheses that have been framed to account for the phenomena of magnetism, I shall only mention that of Mr. Euler ; who supposes that the two principal causes, which concur in producing the wonderful properties of the magnet, are, first, a particular structure of the internal parts of the magnets, and of magnetical bodies ; and, secondly, an external agent or fluid, which acts upon and passes through these pores. This fluid he supposes to be the solar atmosphere, or that subtile matter called ether, which fills our system. But I shall not here expatiate upon theories, which, however ingenious, are allowed to be unsatisfactory. We know that gravitation, electricity, and magnetism exist ; that they have certain properties ; and are productive of certain phenomena : but what their nature is, what their secondary causes, is still among the mysteries, which will, perhaps, be for ever inexplicable. The Contemplative Philosopher will acquiesce in his ignorance with the most awful and devout sentiments of admiration ! And, in every view of the material creation, as well as of the moral government of the Divine Being, he may exclaim, in the language of holy writ, ‘ *O the depth of the riches both of the wisdom and knowledge of God ! how unsearchable are his works, and his ways past finding out !—Of him, and through him, and to him are all things : to whom be glory for ever. Amen.*’



## No. LIII.

## ON EARTHQUAKES.

*Hæc deorum immortalium vox putenda est, cum agri terræ motu quodam contremiscunt, et inusitato aliquid sono incredibilique prædicunt.*

CICERO.

Towers, temples, palaces,  
 Flung from their deep foundations, roof on roof  
 Crushed horrible, and pile on pile o'erturned,  
 Fall total.

MALLET.

THE greater and more formidable phenomena of Nature, whatever modern philosophers may attribute to second causes, were considered by the ancients as the immediate voice of the immortal gods, and the forerunners, in course of some extraordinary event. And thus the Roman orator expresses himself above.—But whether we regard the sentiments of the ancients as the result of rational piety or apprehensive superstition; or whether we consider the most tremendous phenomenon as capable of being explained upon philosophical principles; there is certainly no reason to doubt, that the Omnipotent Being, who first subjected the material world to the influence of certain invariable laws, may so direct the concurrent operations of natural causes, as to evince that he has not left his creation to the fortuitous consequences of Chance, or the irresistible impulse of Necessity; but that even in this sublunar state, the various revolutions, not of empires only, but in the face of the great globe itself, are so many indications, that he incessantly exercises a moral government over his creatures; and that, in the wise dispensations of his providence, every event will finally appear to have been conducive to his gracious

designs, which are the good and happiness of the whole. Earthquakes, therefore, and all other dreadful phenomena, may be considered, in this light, as the immediate operation of the Deity. '*He tooketh on the earth, and it trembleth: he toucheth the hills, and they smoke.*'

His hand the lightning forms :  
He heaves old Ocean, and he wings the storms.

POPE.

Earthquakes, which are unquestionably the most dreadful phenomenon of Nature, have not been confined to such countries, as, from the influence of climate, their vicinity to volcanic mountains, or any other cause, have been considered as more particularly subject to them; but their effects, although not in any degree so extensive and calamitous, have been often felt in this island. I purpose to inquire, in this paper, into the theory and causes of these phenomena, of which the history of all ages and countries has afforded such terrible examples; examples so numberless, indeed, as to justify the emphatical saying of an ancient writer, that 'we walk upon the carcasses of cities, and inhabit only the ruins of our globe.'

The globe around earth's hollow surface shakes,  
And is the ceiling of her sleeping sons.  
O'er devastation we blind revels keep;  
Whose buried towns support the dancer's heel.

YOUNG.

Poetry does not confine its descriptions to the beautiful and pleasing: it selects some of its richest subjects from the grand and majestic, and even from the tremendous and terrific. Dr. Grainger, in his beautiful poem, the Sugar Cane, gives a terrible, but picturesque description of an earthquake in the West Indies, where that phenomenon is very frequent.

Earthquakes, Nature's agonizing pangs,  
Oft shake th' astonied isles; the solfaterre

Or sends forth thick, blue, suffocating steams;  
 Or shoots to temporary flame. A din,  
 Wild, thro' the mountain's quivering rocky caves,  
 Like the dread crash of tumbling planets, roars.  
 When tremble thus the pillars of the globe,  
 Like the tall coco by the fierce North blown,  
 Can the poor, brittle tenements of man  
 Withstand the dread convulsion? Their dear homes  
 (Which shaking, tottering, crashing, bursting, fall)  
 The boldest fly; and, on the open plain  
 Appalled, in agony, the moment wait,  
 When, with disrupture vast, the waving earth  
 Shall whelm them in her sea-disgorging womb.

Nor less affrighted are the bestial kind.  
 The bold steed quivers in each panting vein,  
 And staggers, bathed in deluges of sweat:  
 The lowing herds forsake their grassy food,  
 And send forth frightened, woful, hollow sounds:  
 The dog, thy trusty centinel of night,  
 Deserts his post assigned, and, piteous howls.  
 Wide ocean feels——  
 The mountain waves, passing their custom'd bounds,  
 Make direful, loud incursions on the land,  
 All over-whelming: sudden they retreat,  
 With their whole troubled waters; but, anon,  
 Sudden return, with louder, mightier force;  
 (The black rocks whiten, the vex'd shores resound;)  
 And yet, more rapid, distant they retire.  
 Vast coruscations lighten all the sky,  
 With volumed flames; while Thunder's awful voice,  
 From forth his shrine, by night and horror girt,  
 Astounds the guilty, and appals the good.

And Mr. Mallet, in his fine poem, the *Excursion*, has taken a view of that midland part of Europe, which has been so repeatedly the scene of the most dreadful devastations: I mean Italy and the neighbouring island of Sicily. He introduces a description, replete with the most awful imagery, of a city on the point of being swallowed up by an earthquake; and he expatiates at length upon the signs that precede it, as well as upon its causes and effects. But as the limits of my paper will not permit me to insert this description, I shall proceed immediately to the dif-

2. The second part of the document focuses on the implementation of the proposed changes. It details the steps involved in the process, from the initial planning stage to the final execution. The document highlights the challenges faced during the implementation and provides strategies to overcome them. It also mentions the role of the management team in ensuring the successful completion of the project.

3. The third part of the document discusses the impact of the changes on the organization. It analyzes the benefits and drawbacks of the proposed changes and provides a comprehensive overview of the expected outcomes. The text also mentions the need for continuous monitoring and evaluation to ensure that the changes are implemented effectively and that the organization remains on track.

4. The fourth part of the document discusses the future of the organization. It outlines the long-term goals and objectives of the organization and provides a vision for the future. The text also mentions the need for innovation and creativity to stay ahead of the competition and to ensure the long-term success of the organization.

5. The fifth part of the document discusses the role of the management team in the implementation of the changes. It outlines the responsibilities of the management team and provides a framework for their decision-making process. The text also mentions the need for communication and collaboration between the management team and the staff to ensure the successful implementation of the changes.



their respective advocates have written copiously upon the subject.—Dr. Lister is of opinion, that the cause of thunder, lightning, and earthquakes, is the inflammable breath of the pyrites, which is a substantial sulphur, that will take fire of itself; in a word, as Pliny had observed before, that an earthquake is no more than subterranean thunder<sup>1</sup>.—Dr. Woodward thinks, that the subterranean fire (which is continually elevating the water out of the abyss, or great body of water in the centre of the earth, to furnish dew, rain, springs, and rivers) being diverted from its ordinary course by some accidental obstruction in the pores through which it used to ascend to the surface, becomes by such means, preternaturally assembled, in a greater quantity than usual into one place, and thus causes a rarefaction and intumescence of the water of the abyss, putting it into great commotions, and at the same time making the like effort on the earth; which, being expanded upon the face of the abyss, occasions an earthquake<sup>2</sup>.—M. Amon-ton endeavours to prove, that on the foundation of the new experiments of the weight and spring of the air, a moderate degree of heat may bring the air into a condition capable of causing earthquakes<sup>3</sup>.—Mr. Michell supposes that they are occasioned by subterraneous fires; which, if a large quantity of water should be let out upon them suddenly, may produce a vapour, whose quantity and elastic force may be fully sufficient for this purpose<sup>4</sup>.

But the theory of earthquakes has received considerable alterations and improvements from modern electrical discoveries. Dr. Stukely urges a variety of objections against the common hypothesis that ascribes earthquakes to subterranean winds, fires, or

<sup>1</sup> Philosophical Transactions, No. 157.

<sup>2</sup> Woodward's Natural History of the Earth.

<sup>3</sup> Memoires de l'Academie des Sciences, 1703.

<sup>4</sup> Philosophical Transactions, vol. li.



vapours. He thinks there is no evidence of the  
 vernous structure of the earth, which this hypot  
 requires. Subterranean vapours he judges altoget  
 inadequate to the effects produced by earthqua  
 especially in cases where the shock is of consider  
 extent: for a subterraneous power, capable of  
 ing a surface of earth only thirty miles in diam  
 must be lodged at least fifteen or twenty miles b  
 the surface, and move an inverted cone of solid e  
 whose basis is thirty miles in diameter, and  
 fifteen or twenty miles, which he thinks absol  
 impossible. How much more inconceivable, t  
 that any such power could produce the earthqu  
 of 1755, which was felt in various parts of Eu  
 and Africa, and the Atlantic ocean: or that in  
 Minor, in the year 17, by which thirteen great c  
 were destroyed in one night, and which shook a  
 of earth three hundred miles in diameter; in o  
 to effect which, the moving power, if it had l  
 internal fire or vapour, must have been lodged  
 hundred miles below the surface! Moreover  
 earthquakes the effect is instantaneous, whereas  
 operation of elastic vapour, and the discharge o  
 must be gradual, and require a long space of ti  
 and if they be owing to explosions, they must  
 the surface of the country where they happened,  
 stroy the fountains and springs, and change the co  
 of its rivers, which, he observes, is contradicted  
 history and observation. To all this he adds,  
 the strokes which ships receive during an earthqu  
 must be occasioned by something that could c  
 municate motion with much greater velocity t  
 any heaving of the earth under the sea by the  
 ticity of generated vapours, which would only  
 duce a gradual swell, and not an impulse of  
 water, resembling a thump against the bottom  
 ship, or striking against a rock. Dr. Stukeley, f  
 these and other considerations, deeming the com

hypothesis insufficient, urges a variety of reasons to shew that earthquakes were properly electrical shocks. Among other phenomena, either preceding or attending earthquakes, and which confirmed this opinion, he observed that the weather was usually dry and warm for some time before an earthquake happened, and that the surface of the ground is thus previously disposed for that kind of electrical vibration in which it consists; while at the same time, in some places where earthquakes have happened, the internal parts, at a small depth below the surface, are moist and boggy; and thence he infers that they reach very little below the surface. He adds, that the southern regions are more subject to earthquakes than the northern, on account of the greater warmth and dryness of the earth and air, which are qualities so necessary to electricity. It was also observed, that before the earthquakes at London in 1749, all vegetation was remarkably forward, and electricity is well known to quicken vegetation. They are likewise preceded by frequent and singular appearances of *aurora boreales* and *australes*, and by a variety of meteors, which indicate an electrical state of the atmosphere. And he apprehends, that, in this state of the earth and air, nothing more is necessary to produce an earthquake, than the approach of a non-electric cloud to any part of the earth, when in a highly electrified state, and the discharge of its contents upon it; and that as the discharge from an excited tube occasions a commotion in the human body, so the shock produced by the discharge between the cloud and many miles in compass of solid earth, must be an earthquake, and the snap from the contact the noise attending it<sup>1</sup>.

M. de St. Lazare not only considers earthquakes as electrical, but has endeavoured to prove the prac-

<sup>1</sup> Priestley's History of Electricity, period x, sect. 12.

ticability of forming a *counter-earthquake* and *counter-volcano*, or a method of preventing those convulsions in the bowels of the earth, by means of certain electrical conductors which he describes. But, with respect to this electrical cause, his theory is different from that of Dr. Stukeley. He is of opinion that it is the interruption of the equilibrium between the electrical matter which is diffused in the atmosphere, and that which belongs to the mass of our globe, and pervades its bowels, which produces earthquakes. If the electrical fluid should be superabundant, as may happen from a variety of causes, its current, by the laws of motion peculiar to fluids, is carried toward those places where it is in a similar quantity; and thus it will sometimes pass from the internal parts of the globe into the atmosphere. In such a case, if the equilibrium be re-established with facility, the current produces no other effect than what he calls *ascending thunder*; but if considerable and multiplied obstacles oppose this re-establishment, the consequence is then an earthquake, the violence and extent of which are in exact proportion to the degree of the interruption of the equilibrium, the depth of the electrical matter, and the obstacles that are to be surmounted. If the electrical furnace be large and deep enough, so as to give rise to the formation of a conduit or issue, a volcano will be produced, the successive eruptions of which, he thinks, are no more in reality than electrical repulsions of the matters contained in the bowels of the earth<sup>1</sup>.

Signior Beccaria likewise thinks nearly the same as M. de St. Lazare, that the electric matter which occasions earthquakes, is lodged deep in the bowels of the earth<sup>2</sup>. Dr. Priestley, after having recited

<sup>1</sup> Memoire sur un Para-Tremblement de Terre et un Para-Volcan.

<sup>2</sup> Beccaria Lettere dell' Elettismo.

the opinions of Stukeley and Beccaria on this head, does not absolutely decide which of these two philosophers has advanced the more probable opinion; but he thinks a more feasible general hypothesis than either of them, may be formed out of both. Suppose, says he, the electric matter to be some way or other accumulated on one part of the surface of the earth, and, on account of the dryness of the season, not easily to diffuse itself; it may, as Beccaria supposes, force itself a way into the higher regions of the air, forming clouds in its passage out of the vapours which float in the atmosphere, and occasion a sudden shower, which may further promote the passage of the fluid. The whole surface thus unloaded, will receive a concussion, like any other conducting substance, on parting with, or receiving any quantity of the electric fluid. The rushing noise will likewise sweep over the whole extent of the country. And, upon this supposition also, the fluid, in its discharge from the country, will naturally follow the course of the rivers, and take the advance of any eminences, to facilitate its ascent into the higher regions of the air.

Whether these arguments in favour of the electrical hypothesis be absolutely conclusive, it is not my intention to inquire. But since the above eminent writers have delivered their respective opinions on the subject, a very ingenious naturalist, whose close attention to subterraneous geography, and the variety of new observations and interesting facts he has adduced, render his opinions highly deserving of notice, suggests the idea, that subterranean fire, and steam generated from it, are the true and real causes of earthquakes. And he thinks the elasticity of steam, and its expansive force, are every way capable of producing the stupendous effects attributed to earthquakes, when it is considered that this ex-



pansive force of steam is to that of gunpowder as 140 to 5<sup>1</sup>.

Such are the respective hypotheses concerning earthquakes. I leave my readers to form their own opinions of the probability of each, and shall conclude this paper with the following excellent moral lines:

How greatly terrible, how dark and deep  
The purposes of Heaven! At once o'erthrown,  
White age and youth, the guilty and the just,  
(Oh, seemingly severe!) promiscuous fall.  
Reason, whose daring eye in vain explores  
The fearful providence, confused, subdued  
To silence and amazement, with due praise  
Acknowledges th' Almighty, and adores  
His will unerring, wisest, justest, best! MALLEY.

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## No. LIV.

### ON VOLCANOS AND SUBTERRANEAN FIRES.

Horrificis juxta tonat Ætna ruinis,  
Interdumque atram prorumpit ad æthera nubem,  
Turbine fumantem piceo et caudente favilla,  
Attollitque globos flammæ, et sidera lambit:  
Interdum scopulos avulsaque viscera montis  
Erigit eructans, liquefactaque saxa sub auras  
Cum gemitu glomerat, fundoque exæstuat imo.

VIRGIL.

Ætna roars with dreadful ruins nigh,  
Now hurls a bursting cloud of cinders high,  
Involved in smoky whirlwinds to the sky;

<sup>1</sup> Whitehurst's Inquiry into the Original State and Formation of the Earth.



With loud dislosion, to the starry frame,  
 Shoots fiery globes, and furious floods of flame :  
 Now from her bellowing caverns burst away  
 Vast piles of melted rocks in open day.  
 Her shattered entrails wide the mountain throws,  
 And deep as hell her flaming centre glows.

J. WARTON.

OF all the volcanos, or ignivomous mountains, with which so many parts of the earth abound, Mount *Ætna*, or *Gibel*, in the island of Sicily, is unquestionably the most ancient on record. As *Homer*, however, who flourished about 980 years before Christ, makes no mention of a phenomenon at once so tremendous and extraordinary, this mountain is supposed not to have burned before his time. *Pindar*, who lived 480 years after *Homer*, is the first poet who has given us a description of its fiery eruptions. He has feigned the giant *Typhœus* to be overthrown by *Jupiter*, and overwhelmed by *Ætna*, whose agitations and eruptions were caused by his vain attempts to release himself from its incumbent pressure. Of this fiction, Mr. West has given the following translation :

Now under sulphurous *Cuma's* sea-bound coast,  
 And vast *Sicilia*, lies the shaggy breast ;  
 By snowy *Ætna*, nurse of endless frost,  
 The pillared prop of heaven, for ever pressed :  
 Forth from whose nitrous caverns issuing rise  
 Pure liquid fountains of tempestuous fire,  
 And veil in ruddy mists the noonday skies,  
 While wrapt in smoke the eddy flames aspire,  
 Or gleaming thro' the night with hideous roar,  
 Far o'er the redd'ning main huge rocky fragments pour.

But he, *Vulcanian* monster, to the clouds  
 The fiercest, hottest inundations throws,  
 While, with the burden of incumbent woods  
 And *Ætna's* gloomy cliffs o'erwhelmed he glows.  
 There on his flinty bed outstretched he lies,  
 Whose pointed rock his tossing carcase wounds :  
 There with dismay he strikes beholding eyes,  
 Or frights the distant ear with horrid sounds.

Virgil, who seems, in my motto, to have copied this sublime description, has, in the five lines that follow it, introduced Enceladus in the same situation as Typhœus.

From the consideration of Earthquakes in my last paper, the transition is natural to Volcanos, or burning mountains; especially as the hypothesis, that earthquakes are caused by subterraneous fires, has still so many advocates, and is maintained, in particular, by Mr. Whitehurst, the last ingenious naturalist who has written upon this subject.—This philosopher apprehends that subterraneous fire must, at different times, have existed universally in the bowels of the earth, and that in union with water, or by the expansive power of steam, it has produced the immense continents, as well as the mountains of our globe, and also the universal deluge<sup>1</sup>.

Dr. Watson, bishop of Landaff, has some admirable reflections on this subject in his *Chemical Essays*. ‘The most remarkable changes (says he) which have taken place in the form and constitution of the earth, since the deluge, have probably been produced by subterraneous fires; for it is to their agency that philosophers ascribe volcanos and earthquakes; those tremendous instruments of nature, by which she converts plains into mountains, the ocean into islands, and dry land into stagnant pools.

‘Dr. Hooke formerly had maintained, that all land had been raised out of the sea by earthquakes; and modern philosophers seem to admit his hypothesis, though not, perhaps, in its utmost latitude. Thus one of them is of opinion, that Iceland, which is bigger than Ireland, has been produced by volcanos in the course of several centuries<sup>2</sup>. Another, after

<sup>1</sup> Inquiry into the Original State and Formation of the Earth.

<sup>2</sup> Letters on Iceland by Dr. Uno Von Troil, p. 222.

giving an ingenious conjecture concerning the origin of all the tropical low isles in the South Sea, assures us, that of the higher isles there is hardly one of them which has not strong vestiges of its having undergone some violent alteration by a volcano. Some of them have volcanos still subsisting; others, among which are Otaheite and Huaheine, seem to have been elevated, in remote ages, from the bottom of the sea by subterraneous fires<sup>1</sup>.

‘When these fires were first kindled; by what sort of fuel they are still maintained; at what depths below the surface of the earth they are placed; whether they have a mutual communication; of what dimensions they consist; and how long they may continue, are questions which do not admit an easy decision. The surface of the earth is admirably fitted for the support of the existence and well-being of all the animals which inhabit it. God has given us the ability also to penetrate a very little below this surface; and as the reward of our industry, he has placed within our reach a great variety of useful minerals; but as to the central recesses of the globe, we can never penetrate into them. A gnat essaying the feeble efforts of its slender proboscis against the hide of an elephant, and attempting thereby to investigate the internal formation of the body of that huge animal, is no unapt representation of man attempting to explore the internal structure of the earth by digging little holes upon its surface.

‘But though it will ever be impossible for us to search far into the bowels of the earth, or to imitate in an extensive degree, the great operations which are constantly carrying on beneath its surface, yet it affords a curious mind no mean degree of satisfac-

<sup>1</sup> Observations made during a Voyage round the World by Dr. Forster, p. 151.

tion to be able, by obvious experiments, to form some reasonable conjectures concerning them.

‘ Mr. Lemery<sup>1</sup>, as far as I have been able to learn, was the first person who illustrated, by actual experiment, the origin of subterraneous fires. He mixed twenty-five pounds of powdered sulphur with an equal weight of iron filings; and having kneaded the mixture together, by means of a little water, into the consistence of a paste, he put it into an iron pot, covered it with a cloth, and buried the whole a foot under ground. In about eight or nine hours time the earth swelled, grew warm, and cracked: hot sulphureous vapours were perceived; a flame which dilated the cracks was observed; the superincumbent earth was covered with a yellow and black powder: in short, a subterraneous fire, producing a volcano in miniature, was spontaneously lighted up from the reciprocal actions of sulphur, iron, and water.

‘ That part of this experiment which relates to the production of fire, by the fermentation of iron filings and sulphur when made into a paste, has been frequently repeated since the time of Mr. Lemery. I myself have made it more than once, but I have nothing material to add to his account, except that the flame, when the experiment is made in the open air, is of very short duration; and the whole mass, after the extinction of the flame, continues at intervals, for a longer or shorter time, according to its quantity, to throw out sparks; and that a ladle full of the ignited mass, being dropped down from a considerable height, descends like a shower of red-hot ashes, much resembling the paintings of the eruptions of Mount Vesuvius, which may be seen at the British Museum. It has been observed, that large quantities of the materials are not requisite to make

<sup>1</sup> Cours de Chimie, p. 176.

the experiment succeed, provided there be a due proportion of water: half a pound of steel filings, half a pound of flower of brimstone, and fourteen ounces of water will, when well mixed, acquire heat enough to make the mass take fire.

‘That heat and fire should be generated from the spontaneous actions of minerals upon each other, is a phenomenon by no means singular in nature, how difficult soever it may be to account for it. The heat of putrescent dunghills, of the fermenting juices of vegetables, and, above all, the spontaneous firing of hay not properly dried, are obvious proofs that vegetables possess this property as well as minerals. In both vegetables and minerals, a definite quantity of moisture is requisite to enable them to commence that intestine motion of their parts, which is necessary for the production of fire. Iron and sulphur would remain mixed together for ages without taking fire, if they were either kept perfectly free from moisture, or drenched with too much water; and vegetables in like manner, which are quite dry, or exceedingly wet, are incapable of taking fire while they continue in that state<sup>1</sup>.

‘But though it is certain from the experiment, that mixtures of iron and sulphur, when moistened with a proper quantity of water, will spontaneously take fire; yet the origin of subterraneous fires cannot, with any degree of probability, be referred to the same principle, unless it can be shown that nature has combined together in large quantities iron and sulphur, and distributed the composition through various internal parts of the earth.

‘Now that this is really the case we can have no doubt. There is, perhaps, no mineral more commonly met with than that which is composed of iron

<sup>1</sup> Animal substances, when laid on heaps, have been observed to take fire.



and sulphur. It is found not only upon the face of the earth, but at the greatest depths below it, to which mines have been hitherto driven; not only in England or Italy, Europe or Asia, but in all parts of the world. This mineral is called in some parts of England, copperas-stone; in others, brazil; in others, brass-lumps; in others, rust-balls; in others, horse-gold; in others, marcasite; though naturalists are now, I think, agreed to give that name to such mineral bodies as are angular and crystallized, especially into a cubical form. The scientific name is *pyrites*,—fiery: a denomination expressive enough of the property which this mineral has of striking fire with steel, and of spontaneously taking fire, when laid in heaps, and moistened with water.

‘Sulphur and iron are the chief constituent parts of the pyrites; arsenic, however, is sometimes united with the iron instead of sulphur, and sometimes sulphur and arsenic are both of them combined with iron. The pyrites also, accidentally, contains copper, silver, and perhaps gold: hence the pyrites has been distinguished by mineralogists into various sorts, by attending, either to its internal constitution, as the iron, the copper, the sulphureous, the arsenical pyrites; or to its external figure, as the pyramidal, the cubical, the spherical, the prismatic pyrites; or to its colour, as the gray, white, yellowish, yellow, orange pyrites.

‘Though the reader may have never contemplated the various species of the pyrites in any cabinet of natural history, or taken notice of such kinds as are commonly to be met with in chalk-pits, in beds of clay, or upon the seashore in many places of England, yet the yellowish matter, often adhering to, or mixed with the substance of pit-coal, cannot, surely, have escaped his observation: that matter consists of sulphur and iron, and is a species of the pyrites. So much of this sort of the pyrites

is dug up together with the coal, at Whitehaven, Newcastle, and other places, the people are employed to pick it out from among the coal, lest it should vitiate its quality, and render it less saleable. The pieces of the pyrites which are separated from the coal are not thrown aside as useless, but laid in heaps, for a purpose to be mentioned hereafter; and these heaps, not many years since, took fire both at Whitehaven and in the neighbourhood of Halifax. The same accident was observed above a hundred years ago at Puddle Wharf in London, where heaps of coal which contained much of this pyrites took fire<sup>1</sup>.

‘ Though Lemery was the first person who, by artificial mixtures of sulphur and iron, produced fire, yet that natural mixtures of these substances would spontaneously take fire was known before he made his experiment. Thus, to omit what is said by Pliny and the ancients, we are told by good authority, that one Wilson at Ealand in Yorkshire, about the year 1664 or before, had piled up in a barn many cart-loads of the pyrites, or brass-lumps, as they were called by the colliers, for some secret purposes of his own: the roof of the barn happening to be bad, the pyrites were wetted by the rain; in this state they began to smoke, and presently took fire, and burned like red-hot coal<sup>2</sup>.

‘ We have an account, in the Philosophical Transactions for 1693, of a covetous master of a copperas work at Whitestable in Kent, who, in order to break his neighbour’s work, had engrossed all the pyrites or copperas-stone in the country: he built a shed over two or three hundred tons of these stones, to keep off the rain. In the space, however, of six or seven months, the mass (being probably wetted

<sup>1</sup> Jorden of Miner. Wat. C. xiv.

<sup>2</sup> Power’s *Micros. Obser.* p. 62.

by the moisture of the atmosphere, or by the rain, which, notwithstanding the shed, might have fallen upon it) took fire and burned for a week; it quite destroyed his shed, and disappointed all his hopes of profit; for the pyrites was in part converted into a substance like melted metal, and in part it looked like red-hot stones: all the sulphur was consumed, and the neighbourhood was miserably afflicted by the noxious exhalation which it sent forth.

‘ In the month of August 1751, the cliffs near Charmouth in Dorsetshire took fire, in consequence of a heavy fall of rain after a hot and dry season, and they continued at intervals to emit flame for several years.—These cliffs consist of a dark-coloured bituminous loam, in which are imbedded large quantities of different kinds of the pyrites. The same kind of flame has been frequently observed in the Cornish mines, and this mineral fire sometimes leads to the discovery of a mine; but wherever it is found to exist, the iron pyrites is generally discovered near it<sup>1</sup>.

‘ There are some sorts of earth from which alum is made, which abound so much with the pyrites, that the proprietors of the works are forced to keep them constantly well watered, in order to prevent their taking fire.—But it would be useless to pursue this subject further; we have adduced proof sufficient, that nature furnishes materials, which, under certain circumstances, may become the occasion of subterraneous fires. The requisite circumstances are a proper quantity of the materials, a proper portion of water to moisten them, and, perhaps, a communication with the air may be necessary. A small quantity of the pyrites is sufficient to kindle a fire; water is almost every where found in such great plenty below the surface of the earth, that it con-

<sup>1</sup> Philos. Trans. vol. lii. p. 119.

stitutes one of the greatest impediments to our sinking pits to any great depth; and air, if it should be thought absolutely necessary to the spontaneous firing of the pyrites, may be conceived either to accompany the water in its dripping, or to descend into the innermost parts of the earth through the fissures which are found upon its surface. When a subterraneous fire is once kindled, it may be supported for ages by other substances, as well as by those which first gave rise to it: thus, if a quantity of the pyrites should take fire in a stratum of coal, or of shale, or of any other substance strongly impregnated with bitumen, the fire might continue till the stratum was consumed<sup>1</sup>.

‘There are such a great number of volcanos now subsisting in every quarter of the globe, and so many unequivocal vestiges of others, which in length of time have become extinct, that some philosophers think they have reason on their side in supposing, either that the earth, at some considerable distance below its surface, is surrounded with a stratum of ignited matter of a definite thickness; or that the whole central part of it is nothing but a mass of melted minerals, which every where struggling for vent, bursts forth where there is the least resistance, shivering into rude fragments the superincumbent crust of earth, and deluging with mountainous torrents of liquid fire the adjoining countries.’

This account of the origin of volcanos and subterraneous fires, as it is thus confirmed both by experiments and facts, will, I have no doubt, be very

<sup>1</sup> There are some coaleries on fire now in Scotland, which were on fire in the time of Agricola.—Pennant's *Tour in Scotland*, part ii. p. 201. See an account of the coaleries on fire in Staffordshire, in Dr. Plott's *Nat. Hist. of that county*; and of the substances sublimed from the burning coalpits at Newcastle, in *Philos. Trans.* for 1676.



satisfactory to my readers. In my next paper I shall offer some further observations, which appear to me of no small importance in the discussion of this curious and interesting subject.

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## No. LV.

### FURTHER REFLECTIONS ON VOLCANOS;

WITH A REFUTATION OF SOME OBJECTIONS DEDUCED  
FROM VOLCANIC PHENOMENA, AGAINST THE TRUTH  
OF REVELATION.

The fluid lake that works below,  
Bitumen, sulphur, salt, and iron scum,  
Heaves up its boiling tide. The lab'ring mount  
Is torn with agonizing throes. At once,  
Forth from its side disparted, blazing pours  
A mighty river; burning in prone waves,  
That glimmer thro' the night, to yonder plain.  
Divided there, a hundred torrent streams,  
Each ploughing up its bed, roll dreadful on,  
Resistless. Villages, and woods, and rocks,  
Fall flat before their sweep. The region round,  
Where myrtle walks and groves of golden fruit  
Rose fair; where harvest waved in all its pride;  
And where the vineyard spread its purple store,  
Maturing into nectar; now despoiled  
Of herb, leaf, fruit and flower, from end to end  
Lies buried under fire, a glowing sea!      MALLET.

BESIDE the astonishing explosion of flames and smoke, of cinders and burning rocks, the eruptions of volcanos exhibit a dreadful phenomenon, in prodigious inundations of liquid fire, which bear inevitable destruction with them. The Italians give the name of *lava* to these fiery streams. This lava



consists of a mixture of stones, sand, earth, metallic substances, salt, &c. calcined, rendered fusible, and vitrified, by the fire of the volcanos; but as the mass, of which it originally consists, is very heterogeneous, the lava, when cold, appears under various forms and colours. The purest sort is a hard, black, homogeneous compact glass. There is another species which is hard, heavy, and compact, like marble; susceptible of a very fine polish; and converted, at Naples, to a variety of domestic uses. There is another kind, which is a grosser stone, commonly ash-coloured, and used both for building, and for paving the streets. That which is found on the surface is still more gross and spongy, resembling the scorixæ, or recrements, of melted metals.

It would carry me too far beyond the limits of this paper, if I were to enter into a historical account of the eruptions of volcanos. Those of *Ætna* and *Vesuvius* only would occupy many volumes. The violent eruption of *Vesuvius*, in 1767, is reckoned the 27th, since that which destroyed the cities of *Herculaneum* and *Pompeii*, in the reign of emperor *Titus*; and this eruption of 1767 has been succeeded by several others. Of the eruptions of *Ætna*, Mr. *Oldenburg* has given a historical account in the *Philosophical Transactions*, No. *xlvi.* p. 967. A very great eruption of this mountain was in the year 1669. The progress of the lava, or fiery deluge above described, was at the rate of a furlong a day. It advanced into the sea 600 yards, and was then a mile in breadth. It had destroyed, in forty days, the habitations of 27,000 persons; and of 20,000 inhabitants of the city of *Catanea*, only 3000 escaped. This inundation of liquid fire, in its progress, met with a lake four miles in compass, and not only filled it up, although it was four fathoms deep, but raised it into a mountain. *Borelli*, an ingenious *Neapolitan*, has calculated, that the

matter discharged at this eruption was sufficient to fill a space of 93,838,750 cubic paces. The lava which ran from it is fourteen miles in length, and in many parts, six in breadth. There have been no such eruptions since, although there have been signs of many, more terrible, that preceded it.

A discussion of all the phenomena observable in volcanos, of which there are many in different parts of the world, would be as impracticable, in this paper, as a historical account of their eruptions. I shall, therefore, confine myself now to such observations, as have not been generally attended to. Among the other appearances of our globe, which have afforded room to minute philosophers, and superficial inquirers, to cavil at the truths of revelation, may be included the phenomena of volcanos. A very pleasing and popular writer, in particular, in his description of *Ætna*, has insinuated an objection to the Mosaic account of the creation, by stating in a light somewhat ludicrous, the observations of an ingenious ecclesiastic of Sicily, who was of opinion, that Mount *Ætna* was many thousand years more ancient than Moses had made the earth<sup>1</sup>. The objections of this ecclesiastic, and of the *soi-disant* philosophers who have adopted them, have been fairly stated, and admirably refuted, by a learned prelate, whose writings do equal honour to his age and country<sup>2</sup>. I cannot do better, therefore, than give it in his own words:

‘There is an argument by which some philosophers have endeavoured to overturn the whole system of revelation: and it is the more necessary to give an answer to their objection, as it is become a common subject of philosophical conversation,

<sup>1</sup> Brydone’s Tour through Sicily and Malta.

<sup>2</sup> An Apology for Christianity, by R. Watson, D.D. late bishop of Landaff.

especially among those who have visited the continent. The objection tends to invalidate, as it is supposed, the authority of Moses; by showing, that the earth is much older than it can be proved to be from his account of the creation, and the scripture chronology. We contend that six thousand years have not yet elapsed since the creation; and these philosophers contend, that they have indubitable proof of the earth being at the least 14,000 years old; and they complain that Moses hangs as a dead weight upon them, and blunts all their zeal for inquiry.

The Canonico Recupero, who, it seems, is engaged in writing the history of Mount *Ætna*, has discovered a stratum of lava, which flowed from that mountain, according to his opinion, in the time of the second Punic war, or about 2000 years ago; this stratum is not yet covered with soil sufficient for the production of either corn or vines; it requires then, says the Canon, 2000 years, at least, to convert a stratum of lava into a fertile field. In sinking a pit near Jaci, in the neighbourhood of *Ætna*, they have discovered evident marks of seven distinct lavas, one under the other; the surfaces of which are parallel, and most of them covered with a thick bed of rich earth: now the eruption, which formed the lowest of these lavas (if we may be allowed to reason, says the Canon, from analogy) flowed from the mountain at least 14,000 years ago.—It might be briefly answered to this objection, by denying that there is any thing in the Mosaic account, repugnant to this opinion concerning the great antiquity of the earth; for though the rise and progress of arts and sciences, and the small multiplication of the human species, render it almost to a demonstration probable, that man has not existed longer on the surface of this earth than according to the Mosaic account; yet, that the

earth itself was then created out of nothing, when man was placed upon it, is not, according to the sentiments of some philosophers, to be proved from the original text of sacred scripture<sup>1</sup>; we might, I say, reply, with these philosophers, to this formidable objection of the Canon, by granting it in its full extent: we are under no necessity, however, of adopting their opinion, in order to show the weakness of the Canon's reasoning. For, in the first place, the Canon has not satisfactorily established his main fact, that the lava in question is the identical lava, which Diodorus Siculus mentions to have flowed from *Ætna* in the second Carthaginian war; and, in the second place, it may be observed, that the time necessary for converting lava into fertile fields must be very different, according to the different consistencies of the lavas, and their different situations, with respect to elevation or depression; to their being exposed to winds, rains, and to other circumstances; just as the time, in which the heaps of iron slag (which resembles lava) are covered with verdure, is different at different furnaces, according to the nature of the slag, and situation of the furnace; and something of this kind is deducible from the account of the Canon himself; since the crevices of this famous stratum are really full of rich, good soil, and have pretty large trees growing in them.

‘ But if this should be thought not sufficient to remove the objection, I will produce the Canon an analogy in opposition to his analogy, and which is grounded upon more certain facts. *Ætna* and *Ve-*

<sup>1</sup> It is the opinion of some philosophers, that the submarine volcanos existed in the chaotic mass, antecedent to the creation of the world. The inquisitive reader will find this argument illustrated in Kirwan's *Elements of Mineralogy*, and Whitehurst's *Inquiry into the original State and Formation of the Earth*.

all of them resemble each other in the causes which produce their eruption, in the nature of their lavas, and in the time necessary to mellow them into soil fit for vegetation; or, if there be any slight difference in this respect, it is probably not greater than what subsists between different lavas of the same mountain. This being admitted, which no philosopher will deny, the Canon's analogy will just prove nothing at all, if we can produce an instance of seven different lavas (with interjacent strata of vegetable earth) which have flowed from Mount Vesuvius not in the space of 14,000, but of somewhat less than 1700 years; for then, according to our analogy, a stratum of lava may be covered with vegetable soil in about 250 years, instead of requiring 2000 for the purpose. The eruption of Vesuvius, which destroyed Herculaneum and Pompeii, is rendered still more famous by the death of Pliny, recorded by his nephew, in his letter to Tacitus; this event happened in the year 79; it is not yet then quite 1700 years since Herculaneum was swallowed up: but we are informed by unquestionable authority, that the matter which covers the ancient town of Herculaneum is not the produce of one eruption only; for there are evident marks that the matter of six eruptions has taken its course over that which lies immediately above the town, and was the cause of its destruction. The strata are either of lava or burnt matter, *with veins of good soil between them*<sup>1</sup>.—I will not add another word upon this subject; except that the bishop of the diocese was not much it in his advice to Canonico Recupero—to take care not to make his mountain older than Moses; though it would have been full as well to have shut his mouth with a reason, as to have stopped it with the dread of an ecclesiastical censure.

<sup>1</sup> Sir William Hamilton's Remarks on the Soil of Naples, c. Philos. Trans. vol. lxi.



In this complete refutation of a seemingly irresistible argument, the intelligent and candid reader will observe on what weak foundations are urged many other arguments against revelation, by the patrons of infidelity. A more extensive knowledge of the subject, in this particular instance, would have prevented the hasty petulance and momentary triumph of minds, not sufficiently informed, and not only previously disposed, perhaps, but even anxious and impatient to disbelieve. In like manner, those who are at all conversant with the deistical controversy will recollect how many arguments have been advanced against passages in the sacred writings, which a greater degree of critical learning, and a better acquaintance with the manners, customs, and particular circumstances of those times, would have proved to be frivolous and groundless. Yet these objections, although refuted a thousand times to the satisfaction of all competent judges, will still continue to be urged with confidence and exultation, and as eagerly adopted by ignorance, and (by what is perfectly compatible with infidelity) by credulity itself: so very justly, therefore, may the poet's observation be applied to such speculators in philosophy and religion:

\* A little learning is a dangerous thing.\*

Sir William Hamilton, who resided many years, in a public character, at Naples, and who, with such credit to his country and to himself, has pursued a variety of literary and philosophical researches, has thrown great light on the history of volcanos. In the various letters which he has sent to the Royal Society, on this curious and interesting subject, he has demonstrated that these formidable phenomena fulfil the most beneficial purposes, by serving as spiracles or tunnels to those subterraneous fires, which would otherwise render the dreadful effects

of earthquakes more dreadful still<sup>1</sup>. In one letter, moreover, he has mentioned some particulars which afford an excellent lesson to all who are fond of exploring Nature in her wonderful operations; teaching them not to form rash and premature conclusions from appearances only, but to proceed in their researches with patient and steady investigation. He has demonstrated, that many of the revolutions in the face of the globe have been effected by absolute chemical processes, carried on by Nature, on a more wonderful and extensive scale, than the puny efforts of human art.

‘The gulfs of Gaeta and Terracina (says Sir William<sup>2</sup>) may, in the course of time, become another Campo Felice: for the rich and fertile plain so called, which extends from the bay of Naples to the Appenines, behind Caserta and Capua, has evidently been entirely formed by a succession of such volcanic eruptions. Vesuvius, the Solfaterra, and the high volcanic grounds, on the greater part of which the city of Naples is built, were once probably islands; and we may conceive the islands of Procita, Ischia, Ventotiene, Palmarole, Ponza, and Zannone, to be the outline of a new portion of land intended by Nature to be added to the neighbouring continent; and the Lipari islands (all of which are volcanic) may be looked upon in the same light, with respect to a future intended addition to the island of Sicily.

‘The more opportunities I have of examining this volcanic country, the more I am convinced of the truth of what I have already ventured to advance, which is, that volcanos should be considered

<sup>1</sup> The dread volcano ministers to good;  
Its smothered flames might undermine the world:  
Loud *Ætnas* fulminate in love to man. YOUNG.

<sup>2</sup> Philos. Trans. vol. xxxvi. part 2, for 1786.

in a *creative* rather than in a *destructive* light. Many new discoveries have been made of late years, particularly in the south seas, of islands which owe their birth to volcanic explosions; and some, indeed, where the volcanic fire still operates. I am inclined to believe, that upon further examination, most of the elevated islands, at a considerable distance from continents, would be found to have a volcanic origin; as the low and flat islands appear in general to have been formed of the spoils of sea productions, such as corals, madrepores, &c.

‘ Those who have not had an opportunity of examining a volcanic country, as I have for more than twenty years, would little suspect, that many curious productions and combinations of lavas and tuffas<sup>1</sup> were of a volcanic origin; especially when they have undergone various chemical operations of Nature, some of which have been capable of converting tuffas, lavas, and pumice-stone into the purest clay.

‘ I have observed, that young observers in this branch of natural history have been too apt to fall into the dangerous error of limiting the order of Nature to their confined ideas: for example, should they suspect a mountain to have been a volcano, they immediately climb to the summit to seek for the crater; and if they neither find one, nor any signs of pumice-stone, directly conclude such a mountain not to be volcanic: whereas, only suppose Mount *Ætna* to have ceased erupting for many ages, and that half of its conical part should have mouldered away by time (which would naturally be the consequence) and the harder parts remain in points, forming an immense circuit of mountains (*Ætna* extending its

<sup>1</sup> The tuffa, or tufa, is a stone formed of volcanic ashes, concreted with various other species of stone, in which argil predominates. It is harder than marble, but still porous and spongy.

basis more than 150 miles); such an observer as I have just mentioned would certainly not find a crater on the top of any of these mountains; and his ideas would be too limited to conceive, that this whole range of mountains were only part of what once constituted a complete cone and crater of a volcano. It cannot be too strongly recommended to observers in this, as well as in every other branch of natural history, not to be over hasty in their decisions; not to attribute every production they meet with to a single operation of Nature, when perhaps it has undergone various, of which I have given examples in the island which is the principal subject of this letter<sup>1</sup>. That which was one day in a calcareous state, and formed by an insect in the sea, becomes vitrified in another, by the action of the volcanic fire, and the addition of some natural ingredients, such as sea salts and weeds, and is again transformed to a pure clay, by another curious process of Nature. The naturalist may indeed decide as to the present quality of any natural production; but it would be presumptuous in him to decide as to its former states. As far as I can judge in this curious country, active Nature seems to be constantly employed in composing, decomposing, and recomposing; but surely for all wise and benevolent purposes, though on a scale, perhaps, too great and extensive for our limited comprehension.'

<sup>1</sup> The island of Ponza.



## No. LVI.

## ON THE ART OF NAVIGATION.

Inventâ secuit primus qui nave profundum,  
 Et rudibus remis sollicitavit aquas;  
 Tranquillis primus trepidus se credidit undis,  
 Littora securo tramite summa legens:  
 Mox longos tentare sinus, et linquere terras,  
 Et leni cœpit pandere vela noto:  
 Ast ubi paulatim præceps audacia crevit,  
 Cordaque languentum dedicere metum;  
 Jam vagus irrupit pelago, cœlumque secutus,  
 Ægeas hyemes, Ioniasque domat. CLAUDI

First on the wave the savage sees afloat,  
 With uncouth oars, his just invented boat;  
 With timid eye the tranquil water views,  
 And close to shore his course secure pursues:  
 To catch the southern breeze he next essays,  
 And spreads the sail to cross the spacious bays:  
 Then, by degrees, forgot dejecting fears,  
 No more with aspect dread the sea appears;  
 Intrepid grown, he stretches to the main,  
 Nor can the shores his eager bark detain;  
 But far away, the heav'ns alone his guide,  
 He braves th' Ægean storms and fierce Ionian tide.

LO

IT is not an ill-founded presumption, that all early migrations of mankind were made by land. The ocean, which every where surrounds the habitable earth, as well as the various arms of the sea which separate one region from another, though destined to facilitate the communication between distant countries, seem, at first, to be formed to check the progress of man, and to mark the bounds of that part of the globe to which Nature had confined him. It was long, we may suppose, before men attempted to pass this formidable barrier, and became so skilful



and adventurous as to commit themselves to the mercy of the winds and waves, or to quit their native shore in quest of remote and unknown regions.

Horace seems to have this idea, and to consider the first voyager as possessed of an intrepidity more than human :

*Circa pectus erat, qui fragilem truci  
Commisit pelago ratem*

*Primus ———*

*Necquicquam Deus abscidit*

*Prudens oceano dissociabili*

*Terras, si tamen impiæ*

*Non tangenda rates transiliunt vada.*

*Or oak, or brass, with triple fold,  
Around that daring mortal's bosom rolled,*

*Who first, to the wild ocean's rage,  
Launched the frail bark——*

*Jove has the realms of earth in vain  
Divided by the inhabitable main,*

*If ships profane with fearless pride,  
Bound o'er th' inviolable tide.*

FRANCIS.

Navigation and ship-building are such complicated arts, that they require the ingenuity, as well as experience, of many successive ages, to bring them to any degree of perfection. From the raft or canoe, which first served to carry a savage over the river that obstructed him in the chase, to the construction of a vessel capable of conveying a numerous crew, with safety, to a distant coast, the progress of improvement is immense. Many efforts must have been made, many experiments tried, and much labour and invention employed, before men could accomplish this arduous and important undertaking. The rude and imperfect state in which navigation is still found, among all nations that are not considerably civilized, corresponds with this account of its progress, and demonstrates that, in early times, the art was not so far improved as to enable men to

undertake distant voyages, or to attempt remote discoveries.

Lucretius enumerating the various arts, that were brought to the perfection they had attained in his time, by the observation of successive artists, improving upon new hints and augmenting experience, begins first with this important science :

Navigia, atque agriculturas, moenia, leges,  
Arma, vias, vestes, et cætera de genere horum,  
Præmia, delicias quoque vitæ funditus omneis,  
Carmina, picturas, et dædala signa polire,  
Usus, et impigræ simul experientia mentis  
Paulatim docuit pedetentim progredientis.  
Sic unum quicquid paulatim protrahit ætas  
In medium ratioque in luminis eruit oras.  
Namque aliud ex alio clarescere corde videbant  
Artibus, ad summum donec venêre cacumen.

Thus ships, thus clothes, thus wine, and oil began ;  
And towns, the comfort and support of man ;  
But bettered, all to due perfection brought,  
By searching wits, from long experience taught.  
Thus time, and thus sagacious men produce  
A thousand things or for delight or use ;  
For one thing known does vigorous light impart  
For further search, and leads to height of art.

CREECH.

There will ever be speculators, fond to conjecture concerning the origin of things, however remote in time, and enveloped in obscurity. Various, in course, have been the conjectures concerning navigation ; conjectures, which however unsatisfactory, are yet so far interesting, as they furnish some pleasing scope for ingenious, as well as fanciful reflections. Among the ancients, the poets refer the invention of the art of navigation to Neptune ; others to Bacchus, others to Hercules, others to Jason, and others to Janus, who is said to have constructed the first ship. Historians ascribe it to the Egenites, the Phenicians, and the ancient inhabitants of Britain. Some will

give it, that the first hint was taken from the flight of the kite; others from the motion of fishes in general; and others, from that of the nautilus, a curious shell-fish, in particular; while a learned editor of Virgil's *Georgics* believes, that an alder-tree, grown hollow with age, and falling into the river on which it was planted (for this tree delights in a moist soil and the banks of rivers) gave the first hint toward navigation:

Tunc alnos primum fluvii sensere cavatas:

Then first the rivers hollowed alders bore.

And thus Dryden has poetically delivered his sentiments on the subject:

By viewing Nature, Nature's handmaid, Art,  
Makes mighty things from small beginnings grow:  
The fishes first to shipping did impart,  
Their tail the rudder, and their head the prow.

Some log perhaps upon the waters swam,  
An useless drift, which rudely cut within,  
And hollowed first, a floating trough became,  
And cross some rivulet passage did begin.

In shipping such as this, the Irish kern,  
And untaught Indians on the stream did glide:  
Ere sharp-keeled boats to stem the flood did learn,  
Or fin-like oars did spread from either side.

Add but a sail, and Saturn so appeared,  
When from lost empire he an exile went,  
And with the golden age to Tyber steered,  
Where coin and commerce first he did invent.

Rude as their ships was navigation then;  
No useful compass or meridian known;  
Coasting, they kept the land within their ken,  
And knew the north but when the polestar shone.

Scripture refers the origin of so useful an invention to God himself, who gave the first specimen in

the ark built by Noah: for the raillery which that good patriarch underwent on account of his enterprise, is a sufficient demonstration, that the world was then ignorant of any thing like navigation, and that they even thought it impossible.

But whatever be the origin of this art, and whatever nation may claim the honour of inventing it, or of having rendered it subservient to the noble advantages of commerce, it is certain, that, among all the nations of antiquity, the structure of their vessels was extremely rude, and their method of working them no less defective. They were unacquainted with some of the great principles and operations of navigation, which are now considered as the first elements on which that science is founded. Though that property of the magnet, by which it attracts iron, was well known to the ancients, its most amazing and important virtue of pointing to the poles had escaped their observation. Destitute of this faithful guide, which now conducts the pilot with so much certainty in the unbounded ocean, during the darkness of the night, and when the heavens are covered with clouds, the ancients had no other method of regulating their course, than by observing the sun and stars. Their navigation was, in course, uncertain and timid. They durst seldom quit sight of land, but crept along the coast, exposed to all the dangers, and retarded by all the obstructions, unavoidable in holding such an awkward course. An incredible length of time was requisite for performing voyages, which are now finished in a short space. Even in the mildest climates, and in seas the least tempestuous, it was only during the summer months that the ancients ventured out of their harbour. The remainder of the year was lost in inactivity. It would have been deemed most inconsiderate rashness to brave the fury of the winds and waves during the winter.



Those who have written more diffusively upon the subject, have taken a survey of the progress of discovery and navigation among the ancients; beginning with the Egyptians, and proceeding successively with the Phenicians, Jews, Carthaginians, Greeks, and Romans. From this survey, which may be traced from the earliest dawn of historical knowledge to the full establishment of the Roman empire, the progress of the ancients appears to have been wonderfully slow. It seems neither adequate to what we might have expected from the activity and enterprise of the human mind, nor to what might have been performed by the powers of the great empires, that successively governed the world. If we reject accounts that are fabulous and obscure; if we adhere steadily to the light and information of authentic history, without substituting in its place the conjectures of fancy, or the dreams of etymologists, we must conclude, that the knowledge which the ancients had acquired of the habitable globe was extremely confined. This would sufficiently appear from a review of such parts of the world as they had never explored. But there is a yet more decisive proof of this, in an opinion which universally prevailed among them, that the earth was divided into five regions, which they distinguished by the name of zones. Two of these, the nearest to the poles, they termed frigid zones; and they believed that the extreme cold which reigned perpetually there, rendered them uninhabitable. Another, seated under the line, and extending on either side toward the tropics, they called the torrid zone; and they imagined it to be so burnt up with unremitting heat, as to be equally destitute of inhabitants. On the other two zones, which occupied the remainder of the earth, they bestowed the appellation of temperate; and they taught that these, being the only regions in which life could subsist, were allotted to man for



his habitation. This wild opinion was not a conceit of the uninformed vulgar, or a fanciful fiction of the poets, but a system adopted by the most enlightened philosophers, the most accurate historians and geographers, in Greece and Rome. According to this theory, a vast portion of the habitable globe was pronounced to be unfit for sustaining the human species. Those fertile and populous regions within the torrid zone, which are now known not only to yield their own inhabitants the necessities and comforts of life, with most luxuriant profusion, but to communicate their superfluous stores to the rest of the world, were supposed to be the seat of perpetual sterility and desolation. As all the parts of the globe which the ancients had discovered lay within the northern temperate zone, their opinion that the other temperate zone was inhabited was founded not on discovery, but on reasoning and conjecture. They even believed that, by the insufferable heat of the torrid zone, such an insuperable barrier was placed between the two temperate zones, as would prevent for ever any intercourse between them.

Nevertheless, the discoveries of the Greeks and Romans were still very considerable, when compared to those of remoter times; and, in the second century of the christian era, geography, enriched by new observations, made a very conspicuous figure, under the auspices of Ptolemy the philosopher. The discoveries, subsequent to these times, would lead me into a field of discussion too extensive for this number; which I shall conclude, therefore, with some very ingenious and interesting reflections on the present wonderful perfection of navigation, from Dr. Reinhold Foster's *History of the Voyages and Discoveries made in the North*, translated from the German.

‘Of all the arts and professions which have at any time attracted my notice, none has ever appeared to

be more astonishing and marvellous than that of navigation, in the state in which it is at present; an art which doubtless affords one of the most certain inrefragable proofs of the amazing powers of the human understanding. This cannot be made more evident than when, taking a retrospective view of the tottering, inartificial craft to which navigation owes its origin, we compare it to a noble and majestic edifice, containing 1000 men, together with their provisions, drink, furniture, wearing-apparel, and other necessities for many months, beside 100 pieces of heavy ordnance; and bearing all this vast apparatus safely, and as it were on the wings of the wind, across immense seas to the most distant shores. The following example may serve for the present to delineate at full length, as it were, the idea above alluded to. But first I must premise that a huge, unwieldy log of wood, with the greatest difficulty, and in the most uncouth manner, hollowed out in the inside, and somewhat pointed at both ends, and in this guise set on a river for the purpose of transporting two or three persons belonging to one and the same family across a piece of water a few feet deep, by the assistance of a pole pushed against the ground, cannot with any propriety be considered as the image of navigation in its first and earliest stage. For it seems evident to me, that people in the beginning only took three or four trunks of trees, and fastened them together, and then, by means of this kind of raft, got across such waters as were too deep for them to ford over, and across which they could not well swim with their children, and various kinds of goods which they might wish to preserve from being wet. The canoe, however, is a specimen of the art in a more advanced state, as this kind of craft is capable of having direction given to it, and even of so capital

an improvement as that of having a sail added to it. For this reason I choose this vehicle for a standard, in preference to a mere raft, to which, imperfect as it is, it is so much superior. Let us, then, compare this with a large majestic floating edifice, the result of the ingenuity and united labour of many hundreds of hands, and composed of a great number of well-proportioned pieces, nicely fastened together by means of iron nails and bolts; and rendered so tight with tow and pitch, that no water can penetrate into it. Now, in order to give motion and direction to this enormous machine, some astonishingly lofty pieces of timber have been fixed upright in it, and so many moveable cross pieces have been added to it, together with such a variety of pieces of strong linen cloth, for the purpose of catching the wind, and of receiving its impulse and propelling power, that the number of them amounts to upward of thirty. For changing the direction of these yards and sails, according to particular circumstances, it has been also requisite to add a vast quantity of cordage and tackling; and, nevertheless, even all this would not be sufficient for the perfect direction and government of the vessel, if there were not fastened to the hinder part of it, by means of hinges and hooks, a moveable piece of wood, very small indeed in proportion to the whole machine, but the least inclination of which to either side is sufficient to give immediately a different direction to this enormous large mass, and that even in a storm, so that two men may direct and govern this swimming island with the same or with greater ease than a single man can do a boat. But if, besides, we consider that, in a vessel like this, not a single piece is put in at random, but that every part of it has its determined measure and proportion, and is fixed precisely in that place which

is the most advantageous for it; that, throughout every part of it, there is distributed an astonishing quantity of blocks, stays, and pulleys, for the purpose of diminishing the friction, and of accelerating the motion of these parts; that even the bellying and vaulted part of the fabric, together with its sharp termination underneath, are proportioned according to the nicest calculations, and the most accurately determined rules; that the length and the thickness of the masts, the size of the booms and yards, the length, width, and strength of the sails and tackling, are all in due proportion to one another, according to certain rules founded upon the principles of motion: when we consider all this, I say, our admiration increases more and more at this great masterpiece of human power and understanding. Still, however, there are wanting a few traits to complete this description. A man in health consumes, in the space of twenty-four hours, about eight pounds of victuals and drink: consequently, 8000lb. of provisions are required daily in such a ship. Now let us suppose her to be fitted out for three months only, and we shall find that she must be laden with 720,000lb. of provisions. A large forty-two pounder weighs about 6100lb. if made of brass, and about 5500lb. if of iron; and generally there are twenty-eight or thirty of these on board a ship of 100 guns, the weight of which, exclusive of that of their carriages, amounts to 183,000lb. On the second deck thirty twenty-four pounders, each of which weighs about 5100lb. and therefore all together, 153,000lb. and the weight of the twenty-six or twenty-eight twelve-pounders on the lower deck amounts to about 75,400lb. that of the fourteen six-pounders on the upper deck to about 26,600lb. and beside that, on the round tops, there are even three-pounders and swivels. Now, if to this we add, that the complete charge of a forty-two pounder weighs about 64lb.



and that at least upward of 100 charges are required for each gun, we shall find this to amount nearly to the same weight as the guns themselves. In addition to this, we must reflect, that every ship must have, by way of providing against exigencies, at least another set of sails, cables, cordage, and tacklings, which altogether amount to a considerable weight. The stores, likewise, consisting of planks, pitch, and tow; the chests belonging to the officers and sailors; the surgeon's stores, and various other articles requisite on a long voyage; as also the small arms, bayonets, swords, and pistols, are no inconsiderable load; to which we must finally add the weight of the crew, which is not very trifling; so that one of these large ships carries at least 2162 tons burden, or 4,324,000lb. and at the same time is steered and governed with as much ease as the smallest boat. Now, the consideration of these circumstances alone is sufficient to excite the most serious reflections in a contemplative mind; and yet, if such a ship sailed along the coast only, and never lost sight of the shore, as the navigators of old used to do, we might still be tempted to look upon navigation as an easy and trifling business. But the finding the straightest and shortest way over an ocean of more than 60 or 80 degrees in longitude, and 30 or 40 in latitude; or across a track from 4000 to 6000 miles in extent, by day or by night, in fair weather or in foul, as well when the sky is overcast as when it is clear, and often with no other guide than the compass, and the being able to determine the true position of the ship at sea by the height of the sun, though this latter be enveloped in clouds, or to direct its course by the moon and stars with such exactness and precision as not to make a mistake of the value of half a degree or 30 miles; this at least shows the progress and great perfection of an art practised by a set of people, of whose understand-



ings many conceited and supercilious landmen have but a mean opinion, and whose plain and simple manners they frequently take the liberty of turning into ridicule.

‘A violent storm of wind will make us tremble with fear, even in a strong well-built house, and in the midst of a populous city; yet we have seldom, or never either seen or experienced the vast power of the enraged waves, when beat about by the winds, and dashed against each other till they seem transformed into froth and vapour, and the whole surface of the ocean presents to the eye a confused scene of immense watery mountains and bottomless precipices; and yet on such a sea as this the true seaman, provided he has but a good ship, rides with calm and unshaken courage, and thinks himself as safe in the midst of the ocean as in the best fortified castle.’

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## NO. LVII.

### ON THE NATURE OF THE TIDES.

Alternate tides in sacred order run.

BLACKMORE.

The ebbs of tides, and their mysterious flow,

We, as art's elements shall understand.

DRYDEN.

THE tides of the sea have ever been considered among the most wonderful phenomena in nature. The conjectures of the most ancient philosophers concerning them were equally various, visionary, and wild. Some of them considered the tides as ebullitions occasioned by subterraneous fires, or as

the effects of winds and exhalations, or as the consequence of a rarefaction produced by the beams of the moon, or as proceeding from the interruption of the seas by the continents. It appears, however, that Pliny, Ptolemy, and Macrobius, were not unacquainted with the influence of the sun and moon upon the tides; and Pliny says expressly, that the cause of the ebb and flow is in the sun, which attracts the waters of the ocean; and he adds, that the waters rise in proportion to the proximity of the moon to the earth.

But the moderns have discovered, that all the phenomena of the tides are to be accounted for from the principle of gravitation. All that is requisite to their solution is, that the earth and moon, and every particle of them, mutually gravitate toward each other. Indeed, the sagacious Kepler, long ago conjectured this to be the cause of the tides: (says he) the earth ceased to attract its waters toward itself, all the water in the ocean would rise and flow into the moon: the sphere of the moon's attraction extends to our earth, and draws up the water. This, at that time, was mere conjecture; for Isaac Newton was the first who clearly pointed out the cause of this phenomenon.

The waters of the ocean are observed to flow, at certain hours, from the south toward the north; which motion or flux, which lasts about six hours, the sea gradually swells; so that entering the mouths of rivers, it drives back the river waters toward their heads. After a continual flux of six hours, the sea seems to rest for a quarter of an hour: it then begins to ebb or retire back again, from north to south, six hours more; in which time the waters sinking, the rivers resume their natural course. After a second pause of a quarter of an hour, the sea again begins to flow as before; and thus it has alternately risen and fallen twice a day, since the creation.

I have observed that in the time of Pliny, the tides were known to be under the influence of the sun, in a small degree; but in a much greater, of the moon. It was found, that there was a flux, and reflux of the sea, in the space of twelve hours and forty-eight minutes, which is exactly the time of a lunar day. It was observed, that whenever the moon was in the meridian, or, in other words, as nearly as possible over any part of the sea, that the sea flowed to that part, and made a tide there. On the contrary it was found, that when the moon left the meridian, the sea began to flow back to its former situation, and there might be said to ebb. Thus far the waters of the sea seemed very regularly to attend the motions of the moon. But it appeared, likewise, that when the moon was in the opposite meridian, as far off as on the other side of the globe, there was a tide on this side also; so that the moon produced two tides, one by her greatest approach to, and another by her greatest distance from us: in other words, the moon, in once going round the earth, produced two tides always at the same time; one on the part of the globe directly under her; and the other on the part of the globe directly opposite.

Mankind continued for several ages content with knowing the general cause of these wonders, hopeless of discovering the particular manner of the moon's operation; till, as I before observed, Kepler first conjectured, and Newton demonstrated, that attraction was the principal cause.

The moon has been found, like all the rest of the planets, to attract, and be attracted by the earth. This attraction prevails throughout our whole planetary system. The more matter there is contained in any body the more it attracts; and its influence decreases in proportion as the distance, when squared, increases. This being premised, we must inquire what will follow, supposing the moon in the meri-

dian of any tract of the sea. The surface of water immediately under the moon, is nearer the moon, than any other portion of the globe is; therefore must be more subject to its attraction than the waters any where else. The waters will, therefore, be attracted by the moon, and rise in a bulge whose eminence will be the highest where the attraction is greatest. In order to form this eminence is obvious, that the surface, as well as the bottom, will be agitated; and that wherever the water runs from one part, succeeding waters must run up the space it has left. Thus the waters of the sea, running from all parts, to attend the motion of the moon, produce the motions of the tide; and a high tide at that part wherever the moon comes to it, or to its meridian.

But when the moon travels onward, and ceases to point over the place where the waters were just raised, the cause here of their rising ceasing to operate, they will flow back by their natural gravity, into the lower parts from which they had travelled; and the retiring of the waters will form the ebbing of the sea.

Thus the first part of the demonstration is obvious; since, in general, it requires no great sagacity to conceive, that the waters nearest the moon, will be most attracted, or raised highest by the moon. The other part of the demonstration, namely, that there come to be high tides at the same time, on the opposite side of the globe, and where the waters are farthest from the moon, is not so easy to comprehend. To comprehend this, it must be observed, that the parts of the earth, and its waters, that are farthest from the moon, are the parts of all others the least attracted by the moon: it must also be observed, that all the waters, when the moon is on the opposite side of the earth, must be attracted by the same direction that the earth itself attracts

that is, as it were, quite through the body of the earth, toward the moon itself. This, therefore, being conceived, it is plain, that those waters which are farthest from the moon will have less weight, or gravity toward the centre, than those of any other part on the same side of the globe; because the moon's attraction (which conspires with that of the earth, but which decreases in proportion as the squares of the distances increase) is there least. The waters, therefore, that are farthest from the moon, having less gravity, and being lightest, will be pressed on all sides by those that, having more of the moon's attraction, are heavier: they will be pressed, I say, on all sides; and the heavier waters flowing in, will make them swell and rise in an eminence directly opposite to that on the other side of the globe, caused by the more immediate influence of the moon<sup>1</sup>.

In this manner, the moon, in one diurnal revolution, produces two tides; the one raised immediately under the sphere of its influence, and the other directly opposite to it. As the moon travels, this vast body of waters rears upward, as if to watch its motions; and pursues the same constant rotation. However, in this great work of raising the tides, the sun has no small share: it produces its own tides, constantly every day, just as the moon does, but in a much less degree, because the sun is at an immensely greater distance. Thus there are solar tides and lunar tides. When the forces of these two great luminaries concur, which they always do, when they are in either the same, or in opposite parts of the heavens, they jointly produce a much greater tide, than when they are so situate in the heavens, as each to make peculiar tides of its own. To express the very same thing technically; in the con-

<sup>1</sup> See this, and what follows, illustrated clearly by a reference to a plate in *Bonnycastle's Astronomy*.



junctions and oppositions of the sun and moon, the attraction of the sun conspires with the attraction of the moon; by which means the high spring tides are formed. But in the quadratures of the sun and moon, the water raised by the one is depressed by the other; and hence the lower neap tides have their production. In a word, the tides are greatest in the syzigies, and least in the quadratures.

This theory, well understood, and the astronomical terms previously known, it may be readily brought to explain the various appearances of the tides, if the earth were covered with a deep sea, and the waters uninfluenced by shoals, currents, straits, or tempests. But in every part of the sea, near the shores, the geographer must come in to correct the calculations of the astronomer. For, on account of the shallowness of some places, and the narrowness of the straits in others, there arises a great diversity in the effect, not to be accounted for without an exact knowledge of the place. In the great depths of the ocean, for instance, a very slow and imperceptible motion of the whole body of water will suffice to raise its surface several feet high; but, if the same increase of water is to be conveyed through a narrow channel, it must rush through it with the most impetuous rapidity. Thus, in the English channel, and the German ocean, the tide is found to flow strongest in those places that are narrowest; the same quantity of water being, in this case, driven through a smaller passage. It is often seen, therefore, rushing through a strait with great force; and by its rapidity, considerably raised above that part of the ocean through which it runs.

The shallowness and narrowness of many parts of the sea give rise also to a peculiarity in the tides of some parts of the world: for, in many places, in our own seas in particular, the greatest swell of the tide is *not* while the moon is in its meridian height, and

directly over the place, but some time after it has declined thence. The sea, in this case, being obstructed, pursues the moon with what dispatch it can, but does not arrive with all its waters, till after the moon has ceased to operate. Lastly, from this shallowness of the sea, and from its being obstructed by shoals and straits, we may account for the Mediterranean, the Baltic, and the Black Sea, having no sensible tides. These, although to us they seem very extensive, are not, however, large enough to be affected by the influence of the moon; and, as to their communication with the ocean through such narrow inlets, it is impossible, that in a few hours they should receive and return water enough to raise or depress them in any considerable degree.

In general we may observe, that all tides are much higher, and more considerable in the torrid zone, than in the rest of the ocean; the sea in those parts being generally deeper, and less affected by variable winds, or winding shores. One of the greatest tides we know of is that at the mouth of the river Indus, where the water rises thirty feet in height. How great, therefore, must have been the amazement of Alexander's soldiers at such a strange appearance. They who had been always accustomed before to the scarcely perceptible risings of the Mediterranean, or the minute intumescence of the Black Sea, when made at once spectators of a river rising and falling thirty feet in a few hours, must, no doubt, have felt the most extreme awe, and, as we are told by Quintus Curtius, a mixture of curiosity and apprehension. The tides are also remarkably high on the coasts of Malay, in the straits of Sunda, in the Red Sea, at the mouth of the river St. Lawrence, along the coasts of China and Japan, at Panama, and in the gulf of Bengal. The tides at Batsha in the kingdom of Tonquin, which lies in  $20^{\circ} 50'$  north latitude, are, however, the most remarkable in the world. In this

port there is but one tide and one ebb in twenty-four hours; whereas, as before observed, in all other places there are two. Besides, there, twice in each month there is no tide at all, when the moon is near the equinoctial, the water being for some time quite stagnant. These, with some other odd appearances, were considered by many as inscrutable; but Sir Isaac Newton, with peculiar sagacity, adjudged them to arise from the concurrence of two tides, one from the South Sea, and the other from the Indian Ocean. Of each of these tides there come successively two every day; two at one time greater, and two at another that are less. The time between the arrival of the two greater is considered by him as high tide; the time between the two less, as ebb. In short, with this alone, that great mathematician solved every appearance, and so established his theory as to silence every opposer.

Such is the nature and such the various phenomena of the tides; a subject which I cannot conclude without suggesting how much we are bound to adore the benevolent Creator, not only in the goodness which he manifests in the terraqueous globe, but in his astonishing world of waters. The waters of the sea, it has been observed by philosophers, are kept sweet by their motion, without which they would soon putrefy, and spread universal infection. If we look, therefore, for final causes, a great and obvious one is apparent in the tides. Had the sea been made without motion, and resembling a pool of stagnant water, the nobler races of animated nature would shortly have been at an end. Nothing would then be left alive but swarms of ill formed creatures, with scarce more than vegetable life, and subsisting by putrefaction. Were this extensive bed of waters entirely quiescent, millions of the smaller reptile kinds would there find a proper retreat in which to breed and multiply. They would find there no agi-

tation, no concussion in the parts of the fluid to crush their feeble frames, or to force them from the places in which they were bred; there they would multiply in security and ease, enjoy a short life, and putrefying, thus again give life to numberless others, as little worthy of existence as themselves. But the motion of this great element effectually destroys the number of these viler creatures: its currents and its tides produce continual agitation, the shock of which they are not able to endure; the parts of the fluid rub against each other, destroy all viscidities; and, if I may so express myself, the ocean acquires health by exercise.

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No. LVIII.

ON VARIOUS PHENOMENA OF THE OCEAN.

With wonder mark the moving wilderness of waves,  
From pole to pole through boundless space diffused,  
Magnificently dreadful! where, at large,  
Leviathan, with each inferior name  
Of sea-born kinds, ten thousand thousand tribes,  
Finds endless range for pasture and for sport.

Adoring own

The Hand Almighty, who its channelled bed  
Immeasurable sunk, and poured abroad,  
Fenced with eternal mounds, the fluid sphere;  
With every wind to waft large commerce on,  
Join pole to pole, consociate severed worlds,  
And link in bonds of intercourse and love  
Earth's universal family.

MALLET.

IF we look upon a map of the world, we shall find that the ocean occupies a considerably greater surface of the globe than the land is found to do.



This immense body of waters is diffused round both the old and new continent to the south, and may surround them also to the north, for what we know; but the ice in those latter regions has stopped our inquiries. Although the ocean, properly speaking, is but one extensive sheet of water, continued over every part of the globe, without interruption, and although no part of it is divided from the rest, yet geographers have distinguished it by different names; as the Atlantic or Western Ocean, the Northern, Southern, Pacific, Indian, and German Oceans.

In this vast receptacle, almost all the rivers of the earth ultimately terminate. And yet these vast and inexhaustible supplies do not seem to increase its stores; for it is neither apparently swelled by their tribute, nor diminished by their failure: it continues constantly the same<sup>1</sup>. Indeed, the quantity of water of all the rivers and lakes in the world is nothing

<sup>1</sup> Not only does the *quantity* of water in the ocean remain constantly the same, but, notwithstanding its most violent and incessant motion, it continues *stable* within certain limits. This, however, is what cannot be inferred from observation. For, although in the almost infinite variety of disturbances to which the ocean is liable, from the action of irregular causes, it may appear to return to its former state of equilibrium; yet we may nevertheless apprehend that some extraordinary cause may communicate to it a shock, which, though inconsiderable at its origin, may augment continually, and elevate it above the highest mountains. It is, therefore, interesting to investigate the conditions which are necessary for the absolute stability of the ocean. The celebrated Laplace has effected this; he has demonstrated that the equilibrium of the ocean *must* be stable if its density be *less* than the mean density of the earth; and that is known to be the case. He has likewise determined, by means of his refined analysis, that this stability would cease to exist, if the mean density of the sea *exceeded* that of the earth: so that the stability of the equilibrium of the ocean, and the excess of the density of the terrestrial globe above that of the waters which cover it, are reciprocally connected with each other; and indicate wisdom and contrivance in such a mutual adjustment.



compared to that contained in this prodigious reservoir. And some natural philosophers have carried their ideas on this subject so far, as to assert, in consequence of certain calculations, that, if the bed of the sea were empty, all the rivers of the world flowing into it with a continuance of their present stores, would take up at least 800 years to fill it again to its present height.

Thus great is the assemblage of waters diffused round our habitable globe; and yet, immeasurable as it seems, it is rendered subservient principally to the necessities and conveniencies of so little a being as man. Some have perceived so much analogy to man in the formation of the ocean, that they have not hesitated to assert it was made for him alone. This has been denied by others; and a variety of arguments have been adduced on both sides, in which I do not think it necessary to enter here: for, of this we are certain, that the great Creator has endowed us with abilities to turn this great extent of waters to our own advantage. He has made these things, perhaps, for other uses; but he has given us faculties to convert them to our own. This much agitated question, therefore, seems to terminate here: we shall never know whether the things of this world were made for our use; but we very well know that we were made to enjoy them. Let us then boldly affirm, that the earth and all its wonders are ours; since we are furnished with powers to force them into our service. Man is the lord of the whole sublunary creation; the howling savage, the winding serpent, with all the untameable and rebellious offspring of nature, are destroyed in the contest, or driven at a distance from his habitations. The extensive and tempestuous ocean, instead of dividing or limiting his power, only serves to assist his industry, and enlarge the sphere of his enjoyments. Its billows, and its monsters, instead of presenting a

scene of terror, serve only to excite and invigorate the courage of this intrepid little being; and the greatest danger that man now fears from the deep, is from his fellow-creatures. Indeed, if we consider the human race as nature has formed them, very little of the habitable globe seems to be made for them. But when they are considered as accumulating the wisdom of ages, in commanding the earth, there is nothing so great, nor so terrible. What a poor contemptible being is the naked savage, standing on the beach of the ocean, and trembling at its tumults! How incapable is he of converting its terrors into benefits; or of saying, Behold an element made solely for my enjoyment!—He considers it as an angry deity, and pays it the homage of submission. But it is very different when he has exercised his mental powers; when he has learned to find his own superiority, and to make it subservient to his commands. It is then that his dignity begins to appear, and that the True Deity is adored, for having been mindful of man; for having given him the earth for his habitation, and the sea for his inheritance.

Of the various phenomena of the sea, one of the most obvious is its saltness. Few questions concerning the natural history of our globe, have been discussed with more attention, or decided with less satisfaction, than that concerning the primary cause of it, which had perplexed the philosophers before the time of Aristotle, and surpassed even the great genius of that philosopher. Father Kircher, after having consulted three and thirty authors upon the subject, could not help remarking, that the fluctuations of the ocean itself were scarcely more various than the opinions concerning the origin of its saline impregnation.

The question does not seem capable of admitting

an illustration from experiment ; at least, no experiments have been hitherto made for that purpose ; and, therefore, we may be the less surprised at its remaining nearly as problematical in the present age, as it has been in any preceding. Had any observations been made three or four centuries ago, ascertaining the then saltness of the sea, at any particular time and place, we might now, by making similar observations at the same place, in the same season, have been able to know, whether the saltness, at that particular place, was an increasing, or a decreasing, or an invariable quantity. This kind and degree of knowledge would have served as a clue to direct us to a full investigation of this matter in general. But it is to be regretted that, till very lately, no such observations have been made with any degree of precision.

One of the principal opinions on this subject maintained by modern philosophers, and supported, in particular, by Dr. Halley, is, that since river water, in almost every part of the globe, is impregnated, in a greater or less degree, by sea salt, the sea must have gradually acquired its present quantity of salt from the long continued influx of rivers. The water which is carried into the sea by the rivers, is again separated from it by evaporation, and being dispersed over the atmosphere by winds, it soon descends in rain or vapour upon the surface of the earth ; from which it hastens to pour into the bosom of the ocean the fresh tribute of salt which it has collected in its inland progress. Thus the salt conveyed into the sea not being a volatile substance, nor performing an incessant circulation, like the water which carries it thither, must be a perpetually increasing quantity : and time enough, it is contended, has elapsed since the creation, for the sea to acquire from this its present quantity of salt.

Other philosophers<sup>1</sup>, observing that large beds of fossile salt are not unfrequent in any quarter of the globe; and conceiving, with great probability, the bottom of the sea to be analogous in its formation to the surface of the earth, have undertaken to derive its saltiness from the beds of rock salt, which they suppose to be situate at its bottom; and they are further of opinion, that without such a permanent saline principle, the sea would long since have become insipid, from the fresh water poured into it from an infinity of rivers.

With respect to the first of these opinions, Dr. Watson, bishop of Llandaff, enters into a very ingenious disquisition, to show, that the cause assigned by it for the saltiness of the sea is not adequate to its effect; and, as to the second opinion, he observes, how strange it is, that what, according to the first hypothesis, is thought sufficient to account for the saltiness of the sea, should, in this, be esteemed instrumental in annihilating the saltiness already supposed to exist. Against this last opinion, moreover, he urges an objection of some weight; namely, why the waters of the ocean are not perfectly saturated with salt, if, ever since the creation, they have been exerting their powers upon such permanent masses of rock salt as are thought to be situate at its bottom?

Boyle unites, as it were, the two preceding hypotheses, and takes the saltiness of the sea to be supplied, not only from rocks and other masses of salt, which at the beginning were, or in some countries may yet be found, either at the bottom of the sea, or at the sides, where the water can reach them; but also from the salt which the rivers, rains, and other waters dissolve, in their passage through divers

<sup>1</sup> Mem. de l'Acad. des Sciences de Berlin, Ann. 1760.



parts of the earth, and at length carry with them into the sea.

This opinion, bishop Watson neither condemns nor adopts; but he observes, that Buffon, and the generality of philosophers, acquiesce in it. He adds, that we are inquiring into the cause of a phenomenon, which, it may be said, had no secondary cause at all. 'For it is taken for granted (he continues) in this disquisition, that the water which covered the globe in its chaotic state, was not impregnated with salt as at present, but quite fresh: now this is an opinion concerning a matter of fact, which can never be proved either way; and surely we extend our speculations very far, when we attempt to explain a phenomenon, primeval to, or coeval with, the formation of the earth.

'Bernardine Gomesins, about 200 years ago, published an ingenious treatise upon salt: in this treatise, after reciting and refuting the opinions of Empedocles, Anaxagoras, and Aristotle, upon the subject in question, he proposes his own; wherein he maintains, that the sea was originally created in the same state in which we at present find it, and impregnated, from the very first, with the salt which it contains. Though this hypothesis may be considered by some, rather as a cutting than an untying of the knot, yet it has been embraced by philosophers of great eminence<sup>1</sup>; and it must be owned, that it may be applied to the solution of some phenomena with peculiar propriety. Naturalists assure us, that, though some few species of fishes thrive in fresh water, and some others live alternately in fresh water and salt, yet by far the greatest number cannot exist out of the sea: now, whether we suppose

<sup>1</sup> Why should we attempt to assign a cause for the *saltiness* of the sea, when we never perplex ourselves with an analogous inquiry relative to the *greenness* of grass?



the sea to have become salt from the influx of rivers, or from the gradual solution of beds of rock salt, or from the combined influence of both these causes, it must for some years have remained so exceedingly fresh, that it will not be an easy matter to account for the continuation of the existence of the numberless species of fishes, which cannot live in fresh water. This difficulty is not removed by supposing that fishes do not imbibe any part of the sea's saltness with their food, and attributing the efficacy of sea water in preserving life, to the superior weight with which it compresses the organs of respiration; for this superior weight is as much an effect of the salt dissolved in it, as the saline taste itself. The saltiness of the Caspian Sea, of the lakes of Mexico and Titicaca, and of other large collections of waters, which have no effluent rivers, nor visible communication with the sea, may be as successfully explained upon this hypothesis, *that the sea was at the creation impregnated with salt*, as upon either of the preceding.

‘ Beside the opinions of the causes of the saline impregnation of the sea, which have been mentioned, there is another, which future ages will, probably, see less questionable to adopt than we do: I mean that which maintains, that sea-salt is constantly and abundantly generated, both on the surface of the earth, and in the bosom of the ocean.

‘ But how ineffectual soever our attempts may be to explain the cause of the saltiness of the sea; yet one might have hoped, that in this age of philosophy and curious navigation, the degree of its saltiness in every latitude, and every season of the year, would have been ascertained by accurate experiments. The acquiring knowledge by experiments is a slow and laborious method; but it is, at the same time, a method within our reach: while the theoretical investigation of the proximate cause of any natural

phenomenon often surpasses, and that of its ultimate cause always surpasses the apprehension of the human intellect.'

The saltness of those great collections of waters, that have no effluent rivers, nor visible communication with the sea, has been mentioned in the preceding quotation. But there are other lakes, through which rivers run into the sea; and these, how extensive soever, are, notwithstanding, very fresh: for admitting the first opinion, concerning the influx of rivers into the sea, and consequently of their salts; yet these rivers do not deposit their salts in the bed of the lake, but carry them, with the currents, into the ocean. Thus the lakes Ontario and Erie, in North America, although for magnitude they may be considered as inland seas, are, nevertheless, fresh water lakes, and kept so by the river St. Lawrence, which passes through them.—I shall only mention further, on this head, the opinions of Bernier and Marsigli: the former ascribes the saltness of the ocean to the fossil or mineral salts, brought into it by subterraneous currents, and dissolved in the water: the latter observes, that, in Provence, the bottom of the sea is wholly stony, and is nothing but a continuation of the mountains of the Cevennes; being even found to consist of several strata, among which are salt and pit-coal; and hence he derives the salt and bitterness of the sea-water.

The saltness of the sea has been considered by some as a peculiar blessing from Providence, in order to keep so great an element pure and wholesome. This appears to be the sentiment of Sir Richard Blackmore, in the beautiful lines with which I shall conclude this paper; observing, however, that the saltness of the sea can by no means be considered as a principal cause in preserving its waters from putrefaction; which, in my next essay, I shall endeavour to demonstrate.

What does the sea from putrefaction keep?  
 Should it lie stagnant in its ample seat,  
 The sun would through it spread destructive heat.  
 The wise Contriver, on his end intent,  
 Careful this fatal error to prevent,  
 And keep the waters from corruption free,  
 Mixt them with salt, and seasoned all the sea.  
 What other cause could this effect produce?  
 The brackish tincture through the main diffuse?  
 You, who to solar beams this task assign,  
 To scald the waves, and turn the tide to brine,  
 Reflect, that all the fluid stores, which sleep  
 In the remotest caverns of the deep,  
 Have of the briny force a greater share,  
 Than those above that meet the ambient air.  
 Others, but oh how much in vain, erect  
 Mountains of salt, the ocean to infect.  
 Who, versed in nature, can describe the land,  
 Or fix the place on which those mountains stand?  
 Why have those rocks so long unwasted stood,  
 Since, lavish of their stock, they through the flood,  
 Have, ages past, their melting crystals spread?  
 And with their spoils the liquid regions fed?

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## No. LIX.

### FURTHER REFLECTIONS ON THE OCEAN

And thou, majestic main!  
 A secret world of wonders in thyself!  
 Sound His stupendous praise, whose greater voice  
 Or bids you roar, or bids your roarings fall.

THOMSON.

IN my preceding paper I observed, that the sa-  
 ness of the sea can by no means be considered as  
 principal cause in preserving its waters from putr-  
 faction. The ocean has its currents, like river

which circulate its contents round the globe; and these may be said to be the great agents that keep it sweet and wholesome. Sir Robert Hawkins, one of our most enlightened navigators, gives an account of a calm, in which the sea continuing for some time without motion, began to assume a very formidable appearance. ‘Were it not (says he) for the moving of the sea, by the force of winds, tides, and currents, it would corrupt all the world. The experiment of this I saw in the year 1590, lying with a fleet about the islands of Azores, almost six months; the greatest part of which time we were becalmed. Upon which all the sea became so replenished with various sorts of gellies, and forms of serpents, adders, and snakes, as seemed wonderful; some green, some black, some yellow, some white, some of divers colours, and many of them had life; and some there were a yard and a half, and two yards long; which had I not seen, I could hardly have believed. And hereof are witnesses all the companies of the ships which were then present; so that hardly a man could draw a bucket of water clear of some corruption. In which voyage, toward the end thereof, many of every ship fell sick, and began to die apace. But the speedy passage into our country, was a remedy to the crazed, and a preservative for those that were not touched.’

This shows, sufficiently, how little the saltness of the sea is capable of preserving it from putrefaction. Mr. Boyle, moreover, once kept a quantity of sea water, taken from the English channel, for some time, barrelled up; and, in a few weeks, it began to acquire a fetid smell. He was also assured by one of his acquaintance, who had been becalmed, for about fourteen days, in the Indian ocean, that the water, for want of motion, began to stink; and, that had the calm continued much longer, the stench would probably have poisoned him. It is the mo

tion, therefore, and not the saltness of the sea, that preserves it in its present state of salubrity; and this, very probably, as I have lately observed, by dashing and breaking in pieces the rudiments, if I may so call them, of the various animals, that would otherwise breed and putrefy in the sea.

The saltness of the sea, however, is not unproductive of some advantages. Its waters, being evaporated, furnish that salt which is used for domestic purposes; and although, in some places, it is made from springs, and, in others, dug out of mines, yet, the greatest quantity is made only from the sea. That which is called Bay salt is a stronger kind, made in warm climates, such as Italy, Spain, and the southern provinces of France, by evaporation in the sun: that called common salt is made by evaporation in pans over the fire, and is of a much inferior quality to the former.

Another benefit arising from the quantity of salt dissolved in the sea, is, that it thus becomes heavier, and, consequently, more buoyant. Mr. Boyle, who examined the difference between sea water and fresh, found that the former appeared to be about a forty-fifth part heavier than the latter. Those persons also, who have had opportunities of bathing in the sea, pretend to have experienced a much greater degree of ease in swimming there, than in fresh water. However, as we see that they have only a forty-fifth more of their weight sustained by it, I am inclined to doubt, whether so minute a difference can be practically perceptible. Be this as it may, as sea water alters in its weight from fresh, so also it is found to differ from itself in different parts of the ocean. In general, it is perceived to be heavier, and consequently, salter, the nearer we approach the line<sup>1</sup>.

<sup>1</sup> It appears from some experiments formerly made in a



There is one question, concerning the saltness of the sea, which does not yet appear to be decided; namely, whether it be heavier at the surface, or at the bottom. Mr. Boyle found, that equal bulks of water taken up in the English channel at the surface, and at the depth of fifteen fathoms, were equally heavy, and hence he concludes, that the superficial water was as salt as that at a great depth.

On the other hand, Count Marsigli obtained by evaporating the water a thirty-second part only of its weight of salt from water, taken up on the surface of the sea in the gulf of Lyons, while that taken up at the same time and place, from a great depth, gave him a twenty-ninth part of its weight of salt; and he thence infers, the greater saltness of the sea at the bottom than at its surface. In this conclusion he has been supported by experiments made in the gulf of Bothnia.

There can be no reason to suspect the accuracy with which any of these experiments was made: in different places the facts will probably be different. The river Rhone discharges much fresh water into the gulf of Lyons: this fresh water being lighter than the sea water, will not readily mix itself with it, and for this reason the superficial water will be most diluted by it, and from that circumstance will contain less salt, in a definite quantity, than the water which is at a greater depth. At Northwich the manufacturers of salt pump their brine, which is to be boiled into salt, into a very large circular basin, sunk in the ground, and lined with brick, from which, when its impurities are subsided, it is conveyed to the boiling pans. This basin is exposed to

voyage from Bombay to the East Indies, that the weight of the sea water was the greatest, not precisely at the equator, but where the sun was vertical, and, consequently, in similar circumstances, where the heat was greatest. *Watson's Chem. Essays*, vol. ii. page 114.

the open air, and in case of a great fall of rain or snow, they let off the uttermost parts of the water through a wooden tube, which is at other times stopped with a plug, placed upon a level, nearly with the upper surface of the brine in the basin; what is thus let off is not preserved, but thrown away as useless. This practice proceeds upon the principle I am speaking of, namely, that fresh water is not apt to mix itself, unless it be much agitated, with salt water. The gulf of Bothnia receives rivers from an immense range of mountains, extending themselves to the east, the north, and the west, far beyond the polar circle; and therefore, as in the gulf of Lyons, its surface may be more diluted with fresh water than its middle or bottom. But in the water of the English channel, with which Mr. Boyle made his experiment, the case is very different. This water has a communication with the German ocean on one side, and with the Atlantic on the other; and, from that circumstance, it is subject to such a constant agitation, as will occasion all the fresh water, poured into it by the Thames and Medway, and other rivers of less consequence, to be uniformly diffused through all its substance, so as to render it equally salt at all depths. The constant effect produced on the superficial water of the sea, by the influx of a large river, is somewhat similar to the temporary effect, attending a downfall of rain; the superficial water will be thereby much diluted. It has been observed, that if a quantity of sea water in dry weather weighed 778 grains, an equal quantity immediately after a fall of rain would not weigh above 676 grains, the same quantity of Thames water weighing 659 grains. Hence it may be collected, that the weight of a cubic foot of the sea water before rain exceeded the weight of a cubic foot after rain by 155 ounces.

In the open sea off Shetland, north latitude 60

degrees, equal quantities of water were taken up at the surface, and at the depth of sixty-five fathoms; these different waters yielded by evaporation equal quantities of salt, namely, nearly one twenty-ninth of their weight.

On another occasion, in north latitude 65 degrees, some water taken up from the surface gave nearly one twenty-eighth of its weight of salt, while an equal weight taken up from the depth of 683 fathoms, in the same place, gave only one thirty-second<sup>1</sup>.

It is obvious, that the first of these experiments confirms Mr. Boyle's notion of the sea being equally salt at all depths, and that the second is wholly opposite, both to his opinion, and that of Count Marsigli, so that the question remains still undecided. There is a circumstance, however, which, perhaps, may be sufficient to explain the different results of the last two experiments. The experiments which gave equal quantities of water, taken up at the depth of 65 fathoms, were made on the twelfth of June; the others, which gave more salt from the superficial, than from the deep water, were made on the fourth of September. Now admitting the saltiness of the superficial water, and of water at the depth of 683 fathoms to have been the same, in the beginning of June, why may not the quantity of water, evaporated from the surface of the sea, during the hot months of July and August, have left the superficial water more impregnated with salt than the water at a great depth! It is some confirmation of this notion, that the air in June was only six degrees warmer than the water from the depth of 65 fathoms, and that the air in September, when the experiment was made, was above seventy-six degrees hotter than the water from the depth of 683 fathoms.

<sup>1</sup> Voyage toward the North Pole, in 1773.

The rise of fresh springs at the bottom of the sea, in particular places, may be another reason for our accidentally finding the sea salter at its surface than at any great depth below it. However, neither of the reasons here offered in explanation of the phenomenon are wholly to be relied on; for the fresh water which may accidentally be found at the bottom of the sea will rise up till it becomes as much impregnated with salt, as the water incumbent over it is, and the water at the surface, which is rendered heavier by the sun having evaporated some of its fresh particles, will probably sink downward, and mix itself with the water below it, till the whole mass of water becomes equally heavy, and consequently equally salt. The fact itself, of the sea being in any case salter at the surface than at its bottom, ought to be ascertained by repeated experiments<sup>1</sup>.

But leaving this discussion, which, perhaps, is more curious than useful, there is an advantage arising from the saltiness of the waters of the sea much greater than what has been yet mentioned; which is, that the congelation of them is thus retarded. Some, indeed, have gone so far as to say, that the sea water never freezes: but this is an assertion contradicted by experience. However, it is certain, that it requires a much greater degree of cold to freeze it than fresh water does. It is, therefore, one of the greatest blessings that we derive from this element, that when, at land, all the stores of Nature are locked up from us, we find the sea ever open to our necessities, and patient of the hand of industry.

It must not be supposed, however, that because we never see the sea frozen in our temperate climate, that it is in the same manner open in all parts

<sup>1</sup> Watson's Chem. Essays, vol. ii. page 120.

of our globe. Not to mention, that, at particular seasons, the mouth of the river St. Lawrence, the entrance into the Baltic Sea, &c. &c. are so much frozen over as to be impassable by ships, the vast mountains and fields of ice in the polar regions have, for ages past, been insurmountable obstructions to the daring researches of our ablest navigators.

Of the origin of ice in the frozen seas there are different opinions. Bishop Watson has observed, upon the authority of Captain Weymouth, Captain Cook, and Lord Mulgrave, that very good fresh water has been made from the ice found in those seas; and having stated this, he thus proceeds; 'Notwithstanding these testimonies of our most experienced navigators, concerning the fresh water which they procured from the thawing of the ice they found floating in the sea; yet it might still remain a matter of doubt, whether the ice, from which the water was obtained, had been formed in the sea, and, consequently, whether sea water itself would when frozen yield fresh water. For it might, with some appearance of probability, be said, that the ice had either been formed at the mouths of large fresh water rivers, and thence by tides or torrents drifted into the sea; or that it had been broken by its own weight, from the immense cliffs of ice and frozen snow, which, in countries where there are few rivers, are found in high latitudes to project a great way into the sea'; or lastly, admitting it to be formed in the sea, it might be urged, that it was formed of fresh water, not of salt. Fotherby, in his voyage

<sup>1</sup> *Icebergs* are large bodies of ice filling the valleys between the high mountains.—Large pieces frequently break off from the icebergs, and fall with great noise into the water: we observed one piece, which had floated out into the water, grounded in twenty-four fathom; it was fifty feet high the surface of the water. Phipps's Voyage, page 76



in 1614, esteems snow the original cause of the ice found at sea, for he observed it to be an inch thick upon the surface of the sea; and Captain Cook, from his own observations in the South Sea, was disposed to think, that the vast floats of ice he met with in the spring, were formed from the congelation of snow<sup>1</sup>. Without doubt, the snow which falls upon the surface of the sea, being in a solid state, and, bulk for bulk, lighter than the sea water, will not readily mix itself with it, but may, by a due degree of cold in the atmosphere, be speedily converted into a layer of ice: the upper surface of this first layer of ice, being elevated above the surface of the sea, will receive all the fresh water which falls from the atmosphere in the form of snow, sleet, rain, or dew; by the successive congelation of which, the largest fields of ice may at last be formed. Whether the ice found at sea be formed according to any one or all of these ways, it is evident, that it is produced from an accumulation of congealed fresh water, and that we cannot, from the fresh water procurable from ice thus formed, conclude that the ice of frozen sea water would yield fresh water.

‘To a navigator, it is a matter of little consequence to determine, whence the ice which supplies him with fresh water is produced: he is sure of meeting with more than enough of it for his purpose, and he leaves it to the leisure of philosophers to decide the question, whether congealed sea water will, when thawed, yield fresh water. They have decided it by actual experiments, made with every suitable attention. Some sea water was taken up off the North Foreland, it was exposed to a freezing atmosphere, and it afforded an ice perfectly free from any taste of salt.’ The bishop then, after mentioning some further experiments to the same effect,

<sup>1</sup> Voyage toward the South Pole, vol. ii. page 242.

thus continues: 'It had been long ago asserted by Macrobius, that sea water was never frozen, but that the ice found at sea proceeded from the freezing of the fresh water spread over its surface by the influx of rivers. And in modern times, the opinion, concerning the freezing of sea water, seems to have been admitted with great caution, by our most experienced navigators. They were aware, indeed, that the Baltic and other large seas were frequently frozen quite over, but they appear to have thought, that falls of snow laid a sufficient foundation for the production of that event, 'without its being at all necessary for the sea water to freeze.' I cannot conceive that there was any great occasion for this cautious mode of expression, since it had been observed, above a hundred years ago, that not only sea water, but water containing double the proportion of salt commonly found in our sea water, and more than is contained in the sea water of any climate, might be frozen by the cold prevailing in our atmosphere<sup>1</sup>.'

A very eminent naturalist, who admits the congelation of sea water, has presented us with a very striking description of the wonderful phenomena which the mountains of ice exhibit in these regions of desolation. But as I have already availed myself of this description in my paper *On Winter in the Polar Regions*<sup>2</sup>, I need not repeat it here.

The tides, the saltness of the sea, and mountains of ice, which I have thus described, are not the only phenomena observable in the wonderful world of waters. But I cannot, in this paper, enter into the discussion of any other.

<sup>1</sup> Cook's Voyage, vol. ii. page 242.      <sup>2</sup> No. iv.

## No. LX.

CONCLUSION OF REFLECTIONS ON THE  
OCEAN.

*They that go down to the sea in ships, that do business in great waters ; these see the works of the Lord, and his wonders in the deep.*

PSALMS.

*There are yet hid greater things than these be, for we have seen but a few of his works. We may speak much, and yet come short ; wherefore, in sum, He is all.*

ECCLES.

THE works of nature can excite sensations of pleasure, even in minds the least habituated to reflection. Such, however, are content with mere exterior beauty, and extend not their researches beyond the surfaces of things. The vast expanse of waters appears to them in two aspects only ; as an object of dreadful sublimity in a storm, or of pleasing magnificence in a calm. But the Contemplative Philosopher extends his view far beyond the distant horizon, and far below the agitated surface. He considers the ocean, with the Son of Sirach, as the immense receptacle of wonders yet undiscovered, and of phenomena, which, perhaps, will continue ever unexplained.

There is one very curious phenomenon in the ocean, which has long exercised the sagacity of philosophers. This is the luminous appearance of its surface during the obscurity of the night. M. Bayon, surgeon-major at Cayenne, made a great number of experiments, at different seasons, in order to find out its true cause ; and it always appeared to him, that these luminous points were produced by friction alone. Though he often made use of the best glasses, he could never perceive any insect ;

and, therefore, he is inclined to think, that these luminous points are rather the effects of motion and friction than of animal bodies, as has been supposed by some philosophers<sup>1</sup>. But from the experiments and observations of many learned men<sup>2</sup> on this subject, as far backward as Bacon and Boyle, it appears evident, that various causes, both jointly and separately, produce this phenomenon. The experiments of Mr. Canton<sup>3</sup> prove, that the putrefaction of animal substances produces light and scintillation in the sea. A little white fish placed in sea-water rendered it luminous in the space of twenty-eight hours; and certain quantities of salt, and oil of hartshorn, are known to produce a similar effect in common water. On the other hand, it is certain, that there is in the sea a prodigious quantity of shining insects or animalcules, which contribute to this phenomenon. M. Dagelet, a French astronomer, who returned from Terra Australis in 1774, brought with him several kinds of worms, which shine in water, when it is set in motion; and M. Rigaud affirms, that the luminous surface of the sea, from Brest to the Antilles, contains an immense quantity of little, round, shining polypi, of about a quarter of a line in diameter<sup>4</sup>. Other learned men, who acknowledge the existence of these luminous animals, cannot, however, be persuaded to consider them as the cause of all that light and scintillation which appear on the surface of the ocean. They think that some substance of the phosphorus kind,

<sup>1</sup> *Memoires pour servir à l'histoire de Cayenne et de la Guienne Française.*

<sup>2</sup> Particularly Ozanum, in his treatise concerning Phosphori; Bartholin, in his *Dissert. de Luce Animalium*; Donati, in his *History of the Adriatic Sea*; Nollet, in the *Memoirs of the Royal Academy of Sciences for 1750*; and Vianelli, in his *Nuove Scoperte intorno le Luci notturni dell' Aqua Marina.*

<sup>3</sup> *Philos. Trans.* 1769.

<sup>4</sup> *Journal des Savans* 1770.





fore, that various causes contribute to the light and scintillation of the sea; and that the light which M. Bayon attributed to agitation and friction, is different from that which is extended far and near, which seems to cover the whole surface of the ocean, and produces a very striking and beautiful appearance, particularly in the torrid zone, and in the summer season.

The revolutions produced upon the earth by the sea, form another object of contemplation. It is every day making considerable alterations, either by overflowing its shores in one place, or deserting them in others; by covering over whole tracts of country, that were cultivated and peopled at one time; or by leaving its bed to be appropriated to the purposes of vegetation, and to supply a new theatre for human industry, at another.

In this struggle for dominion between the earth and the sea, the greatest number of our shores seem to defy the whole rage of the waves, both by their height, and the rocky materials of which they are composed, which defend the land, and are only interrupted here and there, to give an egress to rivers, and to afford to our shipping the conveniencies of bays and harbours. In general, it may be remarked, that wherever the sea is most furious, there the boldest shores, and of the most compact materials, are found to oppose it. There are many shores several hundred feet perpendicular, against which, the sea, when swollen with tides or storms, rises and beats with inconceivable fury.

Hence, therefore, we may conceive, how the violence of the sea, and the boldness of the shore, may be said to have made each other. When the sea meets no obstacles, it swells its waters with a gentle intumescence, till all its power is destroyed, by wanting depth to aid its motion. But when its progress is checked in the midst, by the prominence

of rocks, or the abrupt elevation of the land, it dashes with all the force of its depth against the obstacle, and forms, by its repeated violence, the abruptness of the shore which confines the impetuosity. Where the sea is extremely deep, or very much agitated by tempests, it is no small obstacle that can confine its rage; and for this reason we see the boldest shores projected against the deepest waters; all smaller impediments having long before been surmounted and washed away. Perhaps, of all the shores in the world, there is not one so high as that on the west of St. Kilda, which is 600 fathoms perpendicular above the surface of the sea. Here, also, the sea is deep and stormy: so that it requires great force in the shore to oppose its violence. In many parts of the world, and particularly in the East Indies, the shores, though not high above water, are generally very deep, and, consequently, the waves roll against the land with great weight and irregularity. This rising of the waves against the shore, is called the surf of the sea, and, in shipwrecks, is generally fatal to such as attempt to swim on shore. In this case, no dexterity in the swimmer, no float he can use, neither swimming girdle nor cork jacket, will save him: the weight of the superincumbent waves breaks upon him at once, and crushes him with certain ruin. Some few of the natives, however, have the art of swimming, and of navigating their little boats near these shores, where an European is sure of immediate destruction.

In places where the force of the sea is less violent, or its tides less rapid, the shores are generally seen to descend with a more gradual declivity. Over these, the waters of the tide steal by almost imperceptible degrees, covering them for a large extent, and leaving them bare on its recess. Upon these shores, as I have observed, the sea seldom beats

with any great violence, as a large wave has not depth sufficient to float it onward; so that here are to be seen gentle surges only, making calmly toward land, and lessening as they approach. As the sea, in the former description, is generally seen to present prospects of tumult and uproar, here it more usually exhibits a scene of repose and tranquil beauty. Its waters, which, when surveyed from the precipice, afforded a muddy greenish hue, arising from their depth and position to the eye<sup>1</sup>, when beheld from a shelving shore, are the colour of the sky, and seem rising to meet it. The deafening noise of the deep sea, is here converted into gentle murmurs; and, instead of the water dashing against the face of the rock, it advances and recedes, still going forward, but with just force enough to push its weeds and shells, by insensible approaches to the shore.

There are other shores, which have been either raised by art to oppose the inroads of the sea, or, from its gaining ground, are menaced by immediate destruction. The sea being thus seen to give and take away lands at pleasure, is, without question, one of the most extraordinary considerations in natural history. In some places it is seen to obtain the superiority by slow and certain approaches; or to burst in at once, and overwhelm all things in undistinguished destruction: in other places it departs from its shores, and where its waters have been known to rage, it leaves extensive fields covered with verdure.

The formation of new lands, by the sea continually bringing its sediment to one place, and by the accumulation of its sands in another, is easily conceived. Many instances of this are recorded, which I have not room to recapitulate. One alone

<sup>1</sup> Newton's Optics.

will suffice: the whole republic of Holland seems to be a conquest from the sea, and to be rescued, in a manner, from its bosom. The industry of man, however, in the formation of dikes, must here be mentioned; for the surface of the earth, in this country, is still below the level of the sea.

But as the sea has been known to recede from some lands, so it has, by fatal experience, been known to encroach upon others; and, probably, these depredations on one shore, may account for its dereliction of another: for the current which rested upon some certain bank, having got an egress in some other place, no longer presses upon its former bed, but pours all its stream into the new entrance; so that every inundation of the sea may be attended with a correspondent dereliction of another shore.

However this be, we have numerous instances of the inundations of the sea, and of its burying whole provinces in its bosom. One of the most considerable of these, is that which happened in the reign of Henry I., which overflowed the estates of earl Goodwin, in Kent, and formed that celebrated bank, called the Goodwin Sands.

There are some shores on which the sea has made temporary depredations; where it has overflowed, and, after remaining, perhaps, some ages, has again retired of its own accord, or been driven back by the industry of man. The country round the Isle of Ely, in the time of Bede, about ten centuries ago, was one of the most delightful spots in the kingdom. It was not only richly cultivated, and produced all the necessaries of life, but grapes also, that afforded excellent wine. The accounts of that time are copious in the description of verdure and fertility; its rich pastures, covered with flowers and herbage; its beautiful shades and wholesome air. But the sea breaking in, overwhelmed the whole country, and totally destroyed one of the



most fertile valleys in the world. Its air, from being dry and healthful, from that time became very unwholesome; and the small part of the country, that, from being higher than the rest, escaped the deluge, was soon rendered uninhabitable, from its noxious vapours. This country continued thus under water for some centuries; till the sea, at last, by the same caprice which had prompted its invasion, began to abandon it, and has continued, for some ages, to relinquish its former conquests.—Of inundations of the like kind, concerning which history has been silent, we have numberless testimonies of another nature, that prove it beyond the possibility of doubt: I mean those numerous trees, that are found buried at considerable depths, in places which the sea, or rivers, have accidentally overflowed.

But the influence which the sea has upon its shores, is nothing to that which it has upon that great body of earth which forms its bottom. It is at the bottom of the sea that the greatest wonders are performed, and the most rapid changes produced. It is there that the motions of the tides and currents have their whole force, and agitate the substances of which their bed is composed. But these are almost wholly hidden from human curiosity: the miracles of the deep are performed in secret; and we have but little information from its abysses, except what we receive by inspection at very shallow depths, or by the plummet, or from divers, who are known to descend from twenty to thirty fathoms.

The eye can reach but a very short way into the depth of the sea; and that only when its surface is glassy and serene. In many seas, it perceives nothing but a bright sandy plain at bottom, extending for several hundred miles, without an intervening object. But, in others, particularly in the Red Sea,



it is very different ; the whole body of this extensive bed of water is, literally speaking, a forest of submarine plants, and corals formed by insects for their habitation, sometimes branching out to a great extent. Here are seen the madrepores, the sponges, mosses, sea-mushrooms, and other marine productions, covering every part of the bottom.—The bed of many parts of the sea, near America, presents a very different, though a very beautiful appearance. This is covered with vegetables, which make it look as green as a meadow ; and, beneath, are seen thousands of turtles, and other sea-animals, feeding thereon.

The wonders of the great deep are still inexhaustible, if we enter into other extensive subjects that have a close connexion with it, such as zoology and navigation. As these, however, form subjects that should be treated under other heads, I shall conclude this paper, by presenting my readers with some pertinent reflections, by the celebrated M. Savary, in his instructive and entertaining Letters on Greece.

‘ We enjoy the finest weather imaginable ; not a cloud obscures the sky, and a south-east wind wafts us directly toward the port to which our wishes tend. We have now entirely lost sight of land, and, as far as the eye can reach, only view the immense abyss of the waters, and the vast expanse of the heavens. How awful is this sight ! How does it inspire the mind with great ideas ! How adventurous is man, who trusts his fortune and his life to this frail vessel he has built, which a worm may pierce, or a single blast dash to pieces against a rock. Yet in this he braves the fury of the ocean ! But how admirable is his ingenuity ! He commands the winds, enchains them in the canvas, and forces them to conduct him where he pleases. He sails from one end of the world to the other, and traverses the immense liquid

plains, without any signals to direct him. He reads his course in the heavens. A needle, which wonderfully points perpetually to the pole, and the observation of the stars, inform him where he is. A few lines and points mark out to him the islands, coasts, and shoals, which his skill enables him to approach or avoid at pleasure. Yet has he cause to tremble, notwithstanding all his science and all his genius! The fire of the clouds is kindling over his head, and may consume his dwelling. Unfathomable gulfs are yawning beneath his feet, and he is separated from them only by a single plank. His confidence might make us imagine he knew himself immortal; yet he must die—die never to revive again, except in another state of being.’

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No. LXI.

ON THE DECAY AND FALL OF THE  
LEAVES.

How sweetly pleasing to behold  
Forests of vegetable gold!  
How mixed the many chequered shades between  
The tawny mellowing hue, and the gay vivid green!  
FAWKES.

Quam multa in sylvis Autumni frigore primo  
Lapsa cadunt folia. VIRGIL.

Thick as autumnal leaves that strow the brooks,  
In Vallombrosa, where th’ Etrurian shades  
High over-arched imbower. MILTON.

**EACH** *season of the revolving year produces a variety of picturesque appearances peculiar to itself.*

The emotions which affect the mind, while it contemplates scenes which every month contributes to diversify, must consequently be of various kinds, all suitable to the season. The vivid beauties of Spring, the glowing skies of Summer, the fading scenes of Autumn, and the dreary aspect of Winter, excite respectively, vivacity, languor, solemnity, or dejection.

Summer, refulgent 'Child of the Sun' retires, with his 'ardent look,' from our northern regions, in the month of September. Each gaudy flower disappears, and Winter approaches fast. But the gloom of the falling year is in some measure enlivened in that month, especially by the variety of colours, some lively and beautiful, which are then assumed by the fading leaves of trees and shrubs.

Those virgin leaves of purest vivid green,  
Which charmed ere yet they trembled on the trees,  
Now cheer the sober landscape in decay;  
The Lime first fading; and the golden Birch,  
With bark of silver hue; the moss-grown Oak,  
Tenacious of its leaves of russet brown;  
Th' ensanguined Dogwood, and a thousand tints  
Which Flora, dressed in all her pride of bloom,  
Could scarcely equal, decorate the groves.

What a beautiful description is this, of the appearance which some of the trees, in particular, are observed to exhibit! But the great poet of the Seasons, with comprehensive eye, extends his view, and describes the diversified aspect of the changing woods, in one magnificent landscape far diffused around.

The fading many-coloured woods,  
Shade deep'ning over shade, the country round  
Imbrown; a crowded umbrage, dusk and dun,  
Of every hue, from wan-declining green  
To sooty dark. These now the lonesome Muse,  
Low whispering, lead into their leaf-strown walks,  
And give the season in its latest view.

From the gradual change and decay of the leaf, we are next invited to contemplate its fall. This last circumstance is so striking, that the whole declining season of the year is often, in common language, called the *fall*. Here Thomson again presents us with a prospect. What he had before described, the general aspect of the woods, was obvious, perhaps, to every admirer of Nature. But what poet had ever before described so minute a circumstance as the effect which the falling leaf often has upon the contemplative mind?

Now the leaf  
Incessant rustles thro' the mournful grove,  
*Oft startling such as studious walk below,*  
And slowly circles thro' the waving air.  
But should a quicker breeze, amid the boughs  
Sob, o'er the sky the leafy deluge streams :  
Till choaked, and matted with the dreary shower,  
The forest walks, at every rising gale,  
Roll wide the withered waste, and whistle bleak.  
Fled is the blasted verdure of the fields ;  
And, shrunk into their beds, the flowery race  
Their sunny robes resign. Ev'n what remained  
Of stronger fruits, falls from the naked tree ;  
And woods, fields, gardens, orchards, all around  
The desolated prospect thrills the soul.

The Abbé de Lille in his beautiful didactic poem, *Les Jardins*, has likewise been very happy in describing the variegated appearance of the woods, and the philosophic emotions which this vicissitude of Nature has a tendency to inspire. The fine effect of the falling leaf he has evidently borrowed from Thomson :

Que de variété, que de pompe et d'éclat !  
Le pourpre, l'orangé, l'opale, l'incarnat,  
De leurs riches couleurs étalent l'abondance.  
Helas ! tout cet éclat marque leur decadence.  
Tel est le sort commun. Bientôt les aquilons  
Des dépouilles des bois vont joncher les vallons ;  
*De moment en moment la feuille sur la terre,*  
*En tombant, interrompt le rêveur solitaire.*

Mais ces ruines mêmes ont pour moi des attraits.  
 Là, si mon cœur nourrit quelques profonds regrets,  
 Si quelque souvenir vient rouvrir ma blessure,  
 J'aime à mêler mon deuil au deuil de la Nature.  
 De ces bois desséchés, de ces rameaux flétris,  
 Seul, errant, je me plais à fouler les débris.  
 Ils sont passés les jours d'ivresse et de folie ;  
 Viens, je me livre à toi, tendre Melancolie ;  
 Viens, non le front chargé des nuages affreux  
 Dont marche enveloppé le Chagrin ténébreux,  
 Mais l'œil demi-voilé, mais telle qu'en Automne  
 A travers des vapeurs un jour plus doux rayonne :  
 Viens, le regard pensif, le front calme, et les yeux  
 Tout prêts à s'humecter de pleurs délicieux. Chant ii.

What pomp, what vast variety of hues  
 The woodland scenes adorn. The purple deep,  
 Orange, and opal, and carnation bright,  
 To the rapt eye their rich profusion spread.  
 Alas ! this splendour all bespeaks decay.  
 Such is the common lot. The north winds soon  
 Their sylvan spoils will strow along the vales.  
*The leaf incessant flutters to the ground,  
 And, flutt'ring, startles such, who musing stray,  
 Lonely and devious through the solemn shades.*  
 Yet have these leafy ruins charms for me.  
 There, should my heart some poignant woe conceal,  
 And sad Remembrance ope the bleeding wound,  
 How sweet to mingle then my sorrowing gloom,  
 With the deep gloom that saddens all the scene !  
 Wand'ring, recluse, how sweet to tread the spoils  
 Of the stripped woods and withered branches round !  
 The giddy days of gay aspiring Hope,  
 And all my youthful follies, now are fled.  
 Come then, O soothing Melancholy, come ;  
 To thee each moment I devote : But come,  
 Not o'er thy visage hov'ring frightful clouds,  
 Involved in which depressing Sorrow walks,  
 But with eye half-veiled, as in Autumn when  
 Through congregated fogs a brighter sun  
 With sudden radiation cheers the day :  
 O come, with pensive look, and front serene,  
 While the big drops sit trembling in thine eye,  
 Or steal adown thy cheek delicious tears.

Such are the appearances and effects which result



from the gradual decay and fall of the leaves. But the Contemplative Philosopher, not content with general appearances and effects, delights to explore with curious eye, their latent cause. And when he examines the structure of the leaves of trees, and inquires into their uses, with what a grateful heart must he acknowledge, that the all-wise Creator has not designed them for ornament only, but for the most important service in vegetation.

Botanists define a leaf to be a part of a plant extended into length and breadth, in such a manner as to have one side distinguished from the other. They are properly the extreme part of a branch, and the ornament of the twigs. They consist of a very glutinous matter, being furnished every where with veins and nerves. Of the different distinctions of leaves, according to their position and form, above one hundred are enumerated. In all of them, one of the offices is to subtilize and give more spirit to the abundance of nourishing sap, and to convey it to the little buds.

There are two orders of veins and nerves in leaves, one belonging to each surface; and it has been generally observed, that the lower laminae, or under sides of the leaf, have the ramifications larger, and are capable of admitting a liquid to pass through them, which those of the upper surface will not. These two orders of veins are inosculated at several places; but not so closely connected, but that they may be easily separated, after they have been steeped in water a proper time. Both, it is supposed, are destined for very different purposes. The upper lamina, or coat of veins, is thought to consist of air-vessels, through which the perspiring matter is protruded, and by which the air is inspired. This is evident from the clammy substance called honey-dew, which is always found sticking on the upper surface of leaves. The lower lamina is supposed to

be intended for the receiving, preparing, and conveying the moisture, imbibed from the rising vapours of the earth, by which trees and plants are greatly nourished; so that one principal use of leaves is to perform, in some measure, the same office for the support of vegetable life, as the lungs of animals do for the subsistence of animal life. For these respective uses the two surfaces are very differently formed. The upper part is commonly smooth and lucid; the under one frequently covered with hairs, or a soft down, the better to stop and detain the rising vapours, and transmit them to the inner vessels. Where the structure of the leaves is different, it has been demonstrated by experience that their functions alter; for in those leaves whose upper surface is furnished with down or hairs, that upper surface is found to be the receiver and conveyer of the moisture, and not the under one, as in the other plants. If the surface, therefore, of these be altered, by reversing the branches on which they grow, the plants are stopped in their growth until the foot-stalks are turned, and the leaves restored to their former position.

Another of the great functions for which the leaves of trees and plants are designed, is that of their foot-stalks nourishing and preparing the buds of the future shoots, which are always formed at the base of these foot-stalks. During the continuance of the leaves in perfect health, these buds increase in magnitude, and, in the deciduous trees, are brought to maturity before the foot-stalks separate from the buds in Autumn. If the leaves be blighted, or their entire surface cut, although the foot-stalks remain, yet the buds will decay, or not arrive at their proper size, for want of the nourishment which is conveyed to them from the leaves. Whenever, therefore, the trees are divested of their leaves, or those leaves are cut, or otherwise impaired, although it happen in

either case when the buds are nearly formed, yet, if it be before the foot-stalks separate naturally from the branches, the future shoots will be weakened in proportion to the time when this is done. In a word, it is of the utmost consequence not to pull or cut off the leaves of trees or plants, while they retain their verdure, and are in health.

Leaves, moreover, are designed to shade the buds for the future shoots from the sun, which would otherwise exhale and dry up all their moisture. They also shade the young fruit, which is absolutely necessary, during the time of their growth. They throw off, by transpiration, what is unnecessary to the growth of the plant; and this corresponds to the discharge which is made by perspiration in animal bodies. Indeed plants receive and transpire much more in equal time than large animals. The sunflower, for instance, has been found, by repeated experiments, to receive and perspire, in twenty-four hours, seventeen times more than a man.

Air evidently passes in at the leaves, and goes through the whole plant, and out again at the roots. If the leaves have no air, the whole plant will die. This has been proved by experiments with the air-pump. And plants not only draw through their leaves some part of their nourishment from the air, but the leaves also perform the necessary work of altering the water received in at the roots into the nature and juices of the plant; and hence it is that the life of the plants depends so immediately on their leaves. The husbandman often suffers for want of this knowledge. A crop of saintfoin is a very valuable thing, and its root being perennial, will yield him increase many years; but it is often destroyed at first, by suffering it to be indiscreetly fed upon by the sheep, which eating up all the leaves, the root remains without the means of a supply of air, and

the whole plant perishes. This remark has been likewise extended to prove the absurdity of feeding down wheat in the Winter and Spring.

Leaves being thus so necessary, Nature has, in all perennial plants, provided a reversionary stock of them. The leaves of these plants are always formed in Autumn, though they are not unfolded till the following Spring. They then open and increase gradually, in proportion to the motion of the sap, and the quantity of pabulum, or nourishment, it then receives to be circulated. And these leaves of evergreens have also a thin compact skin or cover over their surfaces. They are found by experiment to imbibe and perspire but little in the same space of time, when compared with the deciduous trees and shrubs; and it is chiefly owing to this close covering, and to the small proportion of moisture contained in their vessels, that they retain their verdure, and continue uninjured in the severest frosts; a circumstance which is likewise owing to their oily exterior. Beside these autumnal leaves, there is another set of them formed in Spring, and expanded about Midsummer. These are of infinite service to many trees, particularly to the mulberry, as they save its life when the spring-leaves have been all eaten up by the silkworms.

No plant, indeed, to which Nature has allotted leaves, can live without them, but will certainly die if they are pulled off as soon as they appear. The common grass of our meadows and pastures might seem an exception to this general rule; but it is to be considered, that though the sheep eat this down very close, and take off its leaves as soon as they grow, yet when it is thus devoured by cattle, it is only in the leaf, very little of it growing up into stalk at that time; and therefore less sap is to be purified, and consequently less of the operation allotted

to the leaves required. There is, besides, a constant succession of new leaves growing up in the place of the old ones; and many of these being too short to be bitten off, serve in the place of those which are eaten.

Finally, the leaf serves in a singular manner, as already observed, to nourish the eye or germ of the plant, until, growing by degrees to a greater bulk, it presses the vessels of the foot-stalk together, whereby the juice is by little and little stopped in the leaf till it cannot any more return through the foot-stalk; which, by the cessation of the afflux and reflux of the nutritious juice, grows putrid, and the leaf dies, and falls off. This is the chief cause of the fall of the leaf in Autumn. But other causes are adduced. One of the most obvious is the coldness of the season; for no sooner are the leaves covered with the first hoar-frost, than they are observed to fall in great abundance, and all the trees and plants are stripped of their verdant honours. The cold, it is said, causes a stagnation of the sap in plants, and prevents its transpiration by the leaves. But this explanation would be insufficient without the solution already given; for the leaves will certainly fall, although it do not freeze during the whole winter; nor can the shelter of greenhouses prevent this annual decay and fall.

But whatever be the cause of this vicissitude in the vegetable reign, the decay and fall of the leaves have been favourite themes with poets and philosophers. The first they furnish with beautiful descriptions; the latter with solemn contemplations and pathetic moral sentiment. There is something, indeed, extremely melancholy in that gradual process by which the trees are stripped of all their beauty, and left so many monuments of decay and desolation. Homer, the venerable father of poetry, has deduced from this succession of springing and falling leaves,



a very apposite comparison for the transitory generations of men :

Like leaves on trees the race of man is found,  
Now green in youth, now withering on the ground.  
Another race the following spring supplies,  
They fall successive, and successive rise ;  
So generations in their course decay,  
So flourish these, when those are past away.      POTE.

The autumnal forest, it has been justly observed<sup>1</sup>, ‘ is an instrument easily untuned. One frosty night, or parching blast, may introduce some striking discord ; though, on the other hand, it is true, by softening some discordant tint, it may as easily introduce a harmony which did not exist before. Here art comes to the aid of nature. The pencil fixes the scene in the happy moment ; and the fading tints of autumn become perennial.

‘ I have known some planters endeavour, in their improvements, to range their trees in such a manner, as, in the wane of the year, to receive all the beauty of autumnal covering. The attempt is vain, unless they could so command the weather as to check, or produce at pleasure, those tints, which nature hath subjected to so many accidents. A general direction is all that can be given. Oak is rarely in discord ; but beech and elm can as rarely be depended on. All must be left to chance ; and after the utmost that art can do, the wild forest, with its casual discords and monotonies, will present a thousand beauties, which no skill of man can rival.

‘ Thus the beauties of the waning year are fixed rather by the weather than the calendar. We often see them vanish in October ; and we sometimes see a fine autumnal effect in the beginning of November :

<sup>1</sup> See Gilpin’s *Forest Scenery*, vol. i, p. 269.

**LXL. *Decay and Fall of the Leaves.* 313**

y, even later, we may trace the beauties of the  
clining year, and

Catch the last smile  
Of autumn beaming o'er the yellow woods.

Even when the beauty of the landscape is gone,  
 charms of autumn may remain. After the rage  
summer is abated, and before the rigours of win-  
 are yet set in, there are often days of such hea-  
 ly temperature, that every mind must feel their  
 act. Thomson, to whom the beauties of nature  
 re familiar, thus describes a day of this kind:—

The morning shines,  
Serene in all its dewy beauties bright,  
Unfolding fair the last autumnal day.  
O'er all the soul its sacred influence breathes,  
Inflames imagination, through the breast  
Infuses every tenderness, and far  
Beyond dim earth exalts the swelling thought.

the picturesque beauties of autumn we may add,  
t the setting sun, at that season, is commonly  
ier than when the days are of the same length in  
spring, or, indeed, at any other season.'

## No. LXII.

ON THE CHAIN OF BEINGS IN THE  
UNIVERSE.

Look round our world ; behold the chain of love  
Combining all below and all above. POPE.

But how preserved  
The chain unbroken upward, to the realms  
Of incorporeal life—those realms of bliss  
Where Death hath no dominion ? YOUNG.

ALL the beings in this world, whether animal or vegetable, have a mutual connexion and dependence. There is a graduated scale or chain of existence, not a link of which, how insignificant soever, could be broken, without affecting the whole. Unthinking men are apt to wonder, for instance, at the design of Providence in producing certain insects and reptiles. They do not consider, that the annihilation of any one species of these creatures, although some of them are even noxious to man, would make a blank in the creation, and prove destructive to other creatures that feed upon them. The destruction of these, in their turn, would occasion the destruction of other species ; and the system of devastation would gradually proceed, till man himself were extirpated, and the earth left destitute of animation.

He, who through vast immensity can pierce,  
See worlds on worlds compose one universe,  
Observe how system into system runs,  
What other planets circle other suns,  
What varied being peoples every star,  
May tell why Heav'n has made us as we are.  
But of this frame the bearings and the ties,  
The strong connexions, nice dependencies,

Gradations just, has thy pervading soul  
Looked through? Or can a part contain the whole?

POPE.

Man is certainly the chief link in the chain of animals; and all the other links descend from him by almost imperceptible gradations. As a rational animal, highly improved by science and the arts; and, more particularly, from the capacity of religious knowledge, which, of all the creatures of this world, he alone possesses; he is, in some measure, related to Beings of a superior order, wherever they exist. By contemplating the works of creation, he rises to some faint idea of its great Author.—But why, it has been asked, do not men possess the capacity and powers of angels? With the same propriety, it may be asked, why have not brutes the intellectual faculties of men? Questions of this kind proceed from the petulance of ignorance and presumption. Every creature is perfect, according to its destination. Exalt or depress any order of beings, the whole system, of course, would be deranged, and a new world would be necessary to contain and support them. Particular orders of beings should not be considered separately, but by the rank they hold in the general system. From man to the most minute animalcule that can be discovered by the microscope, the chasm seems to be infinite: but that chasm is actually filled up with sentient beings, of which the lines of discrimination are almost imperceptible; and all of them are endued with certain degrees of perfection proportioned to their respective stations in the universe.

See, through this air, this ocean, and this earth,  
All matter quick, and bursting into birth.  
Above, how high progressive life may go!  
Around, how wide! how deep extend below!  
Vast chain of being! which from God began,  
Natures ethereal, human, angel, man,

Beast, bird, fish, insect, what no eye can see,  
 No glass can reach; from Infinite to thee,  
 From thee to nothing.

POPE.

Even among mankind, which is a particular species, the scale of intellect is very extensive; the degrees of intelligence extremely varied. What a difference, for instance, between the enlightened philosopher of Europe, and the brutal savage of New Holland! Still, however, Nature observes, for the wisest purposes, an uniform plan of gradation. Were all men philosophers, the business of life could not be executed, and neither society, nor even the species, could long exist. Industry, various degrees of knowledge, different dispositions, and different talents, are great bonds of society. Nature, indeed, has formed the human species, as it were, into casts or ranks. To some she gives superior genius and mental abilities; and, even of these, the views, the pursuits, and the tastes, are wonderfully diversified.

Not alike to every mortal eye  
 Is this great scene unveiled: For while the claims  
 Of social life to different labours urge  
 The active powers of man, with wisest care  
 Hath Nature on the multitude of minds  
 Impressed a various bias; and to each  
 Decreed its province in the common toil.  
 To some she taught the fabric of the sphere,  
 The changeful moon, the circuit of the stars,  
 The golden zones of heaven. To some she gave  
 To search the story of eternal thought;  
 Of space, and time; of fate's unbroken chain,  
 And will's quick movement. Others by the hand  
 She led o'er vales and mountains, to explore  
 What healing virtue dwells in every vein  
 Of herbs or trees. But some to nobler hopes  
 Were destined: some within a finer mould  
 She wrought, and tempered with a purer flame.  
 To these the Sire Omnipotent unfolds,  
 In fuller aspects and with fairer lights,



This picture of the world. Through every part  
 They trace the lofty sketches of his hand :  
 In earth, or air, the meadow's flowery store,  
 The moon's mild radiance, or the virgin's mien  
 Dressed in attractive smiles, they see pourtrayed  
 (As far as mortal eyes the portrait scan)  
 Those lineaments of beauty which delight  
 The Mind Supreme. They also feel their force,  
 Enamoured : they partake the eternal joy.

AKENSIDE.

In the talents and qualities of quadrupeds of the same species, there are often remarkable differences. These differences are conspicuous in the various races of horses, dogs, &c. Even among the same races, some are bold, sprightly, and sagacious : others are comparatively timid, phlegmatic, and dull.

Our knowledge of the chain of intellectual and corporeal beings is very imperfect ; but what we do now affords the most exalted ideas of the variety and progression which reign in the universe. An impenetrable cloud prevents our discerning the most beautiful and magnificent parts of this immense chain of beings. I shall endeavour, however, to point out a few of its more obvious links, which fall under our limited observation.

Man, even by his external qualities, stands at the head of this world. His relations are more extensive than those of any other animal : his form is more advantageous. His intellectual powers, when improved by society, science, and religion, exalt him so high, that, if no degrees of excellence existed among his own species, he would leave a great void in the chain of beings. Were we to consider the characters, the manners, and the genius of different nations, of different provinces and towns, and even of the members of the same family, we should imagine that the species of men were as various as the numbers of individuals. What gradations, as I have already observed, may be traced between the stupid savage

and the enlightened philosopher ! Here the distance is immense ; but Nature has filled the whole with almost infinite shades of discrimination.

In descending the scale of animation, the next step (which it is humiliating to remark) is very short. Man, in his lowest condition, is evidently linked, both in the form of his body and the capacity of his mind, to the large and small orangutans. These again, by another slight gradation, are connected to the apes, which, like the former, have no tails. From the apes to the baboons the interval is hardly perceptible. The true apes have no tails ; and those of the baboons are very short. The monkeys, which form the next link, have long tails, and terminate this partial chain of imitative animals, which have such a mortifying resemblance to our frame and manners.

When we examine the characters by which beings are distinguished from each other, we perceive that some of them are more general, and include a greater variety than others. Hence are derived all our distributions into classes, orders, genera, and species. Between two classes, or two genera, however, Nature always exhibits intermediate productions, so closely allied, that it is extremely difficult to ascertain to which of them they belong. The polypus, which multiplies by shoots, or by sections, from its body, connects the animal to the vegetable kingdom. Those worms, which lodge in tubes composed of sand, seem to link the insects to the shell and crustaceous animals. Shell animals and crustaceous insects make, likewise, a near approach to each other. The muscles and instruments of motion in both, are attached to external instead of internal bones. From reptiles, the degrees of perfection in animal life and powers proceed in a gradual but not imperceptible manner. The number of their organs of sense, and the general conformation of their bodies,

begin to have a greater analogy to the structure of those animals which we are accustomed to consider as belonging to the more perfect kinds. The snake, by its form, its movements, and its mode of living, is evidently connected with the eel and the water-serpent. Like reptiles, fishes, in general, are covered with scales, the colours and variety of which often enable us to distinguish one species from another. Their fins, from the medium in which they live, are analogous to the wings of birds. Their heads, like those of reptiles, are immediately connected to their bodies, without the intervention of necks. The flying fishes, whose fins resemble the wings of bats, form one link which unites the fishes to the feathered tribes. Aquatic birds, by a gentle gradation, succeed the flying fishes.

The transition from fishes to quadrupeds is almost imperceptible. The sea-lion, the morse, the whale, the crocodile, the turtle, the seal, have such resemblance both in their external and internal structure, to terrestrial quadrupeds, that some naturalists, in their methodical distributions, have ranked them under the same class of animals. The bat and the flying squirrel, which traverse the air by means of membranous instead of feathered wings, evidently connect quadrupeds with birds. The ostrich, the cassowary, and the dodo, which rather run than fly, form another link between the quadruped and the bird.

Far as creation's ample range extends,  
The scale of sensual, mental powers ascends :  
Mark how it mounts to man's imperial race,  
From the green myriads in the peopled grass ;  
What modes of sight betwixt each wide extreme,  
The mole's dim curtain, and the lynx's beam :  
Of smell, the headlong lioness between,  
And hound sagacious on the tainted green :  
Of hearing, from the life that fills the flood,  
To that which warbles through the vernal wood !

The spider's touch, how exquisitely fine !  
Feels at each thread, and lives along the line !  
In the nice bee, what sense so subtly true  
From poisonous herbs extracts the healing dew,  
How instinct varies in the groveling swine,  
Compared, half-reasoning elephant, with thine !  
'Twixt that, and Reason, what a nice barrier !  
For ever separate, yet for ever near !  
Remembrance and Reflection how allied ;  
What thin partitions Sense from Thought divide !  
And middle natures, how they long to join,  
Yet never pass th' insuperable line !

POPE

Among the variety of reflections to which this subject may lead us, one of the most striking is, the consideration of the arrogance and folly of man, in supposing himself to be the masterpiece, and sole end, of the whole creation. How low and contracted our views, to imagine that the fulness of the Divine Power and Wisdom has been exhausted upon a frail and impotent creature, who probably is the lowest in the scale of rational beings ! It is much more consistent with the attributes of the great Creator to suppose, that we, who are next to the beasts of the field, are far from making the nearest approaches, without any intermediate order of beings, to the all-perfect Deity ; that, as an uninterrupted chain of beings descends from man to brutes, from brutes to imperceptible insects, it ascends, likewise, by a beautiful gradation, from man to angel, to archangel, and to inconceivable orders of celestial spirits. How sublime, how unutterable the idea of such a gradation from man, to the most exalted of those beings. Yet the dignity of these bears no more proportion to that of Him who dwells in unapproachable glory, than a gilded cloud, on which the evening sun has impressed his beams, and enriched with beautiful stains, does to that great abyss of light from which it derives its reflected beauty. He can still create beings, which shall as much surpass

archangels of the highest order, as they surpass the most despicable insect: for every nature, how exalted soever, must be infinite descents below an All-perfect Being.

Considerations of this kind open to man the blissful scenes of immortality. They teach him to look up to the Supreme Being with the most profound veneration, the most heartfelt gratitude, and the most levout aspirations; and, by gradually improving his moral and intellectual powers, to rise, at last, from his present station in the universe, to the rank and elicity of celestial beings.

Say, why was man so eminently raised  
Amid the vast creation; why empowered  
Through life and death to dart his watchful eye,  
With thoughts beyond the limit of his frame;  
But that the Omnipotent might send him forth,  
In sight of angels and immortal minds,  
As on an ample theatre to join  
In contest with his equals, who shall best  
The task achieve, the course of noble toils,  
By wisdom and by mercy preordained?  
Might send him forth the sov'reign good to learn;  
To chase each meaner purpose from his breast?  
And through the mists of passion and of sense,  
And through the pelting storms of chance and pain,  
To hold straight on with constant heart and eye,  
Still fixed upon his everlasting palm,  
The approving smile of Heaven?

For, from the birth'  
Of human kind, the sov'reign Maker said,  
That not in humble, nor in brief delight,  
Not in the fleeting echos of renown,  
Power's purple robes, nor Pleasure's flowery lap,  
The soul should find contentment; but, from these  
Turning disdainful to an equal good,  
Through Nature's opening walks enlarge her aim,  
Till every bound at length should disappear,  
And infinite perfection fill the scene.

AKENSIDE.

These are thoughts that make man Man,  
The wise illumine, aggrandize the great.



How great, in the wild whirl of Time's pursuits,  
 To stop, and pause, involved in high presage,  
 Through the long vista of a thousand years,  
 To stand contemplating our distant selves,  
 As in a magnifying mirror seen,  
 Enlarged, ennobled, elevate, divine!  
 To prophesy our own futurities!  
 To gaze in thought on what all thought transcends!  
 To talk, with fellow-candidates, of joys  
 As far beyond conception as desert!

And, oh, how great  
 To mingle interests, converse, amities,  
 With all the sons of Reason, scattered wide  
 Through habitable space, wherever born,  
 Howe'er endowed! To live free citizens  
 Of universal nature! To lay hold  
 By more than feeble faith on the Supreme!  
 To rise in science, as in bliss,  
 Initiate in the secrets of the skies!  
 To read creation; read its mighty plan!  
 The plan, and execution, to collate!  
 To see, before each glance of piercing thought,  
 All cloud, all shadow, blown remote; and leave  
 No mystery—but that of Love Divine!      YOUNG.

No. LXIII.

ON THE PRINCIPLE OF ASSOCIATION.

Far, far away, whose passions would immure,  
 In your own little hearts, the joys of life !  
 Know, for superior ends, th' Almighty Power  
 Breathes o'er the foodful earth the breath of life,  
 And forms us manifold; allots to each  
 His fair peculiar ; wisdom, wit, and strength ;  
 Wisdom, and wit, and strength, in sweet accord,  
 To aid, to cheer, to counsel, to protect,  
 And twist the mighty bond. Thus feeble man,  
 With man united, is a nation strong ;  
 Builds towery cities, satiates every want,  
 And makes the seas profound, and forests wild,  
 The gardens of his joys. DYER.

Nor think, in Nature's state they blindly trod ;  
 The state of Nature was the reign of God :  
 Self Love and Social at her birth began,  
 Union the bond of all things, and of man. POPE.

IN my former paper I was engaged in the sublime  
 contemplation of the chain of beings in the universe ;  
 in which an infinite variety of orders rise,

From the mute shell-fish gasping on the shore,  
 To men, to angels, to celestial minds. AKENSIDE.

I will now descend to our world, that comparatively  
 minute part of our creation, and inquire into the  
 principle of Association, by which the sovereign  
 Ruler of All has connected its innumerable in-  
 habitants.

Some learned men have contended, that the na-  
 tural state of man is a state of solitude and war.  
 Others maintain, on the contrary, that the state of  
 man in society is his natural state ; and to this  
 opinion I am led to accede, by an attentive ob-

servation, not of man alone, but of many inferior orders of animated nature.

Love, the first principle of the universe, and of all created beings, inspires them with a natural inclination to unite. The birds that fly in the air, the animals that inhabit the earth, the fishes that rove in the water, all live in a kind of society, which has laws proportionate to their nature and their wants. Beasts, birds, and the inhabitants of the floods, assemble at the approach of danger. Bees assist each other in their exigencies; and a cock, in a farm-yard, will defend the hen of his fellow-cock. In a word, we have only to observe the face of Nature, in order to be convinced, that all animals have an idea of property; an idea, which is the necessary and absolute consequence of self-love, of the desire of preservation, and of happiness, which is natural to every being.

God, in the nature of each being, founds  
 Its proper bliss, and sets its proper bounds :  
 But as he framed a whole, the whole to bless,  
 On mutual wants, built mutual happiness;  
 So from the first, eternal order ran,  
 And creature linked to creature, man to man.  
 Whate'er of life all-quickeneth ether keeps,  
 Or breathes through air, or shoots beneath the deeps,  
 Or pours profuse on earth, one nature feeds  
 The vital flame, and swells the genial seeds.  
 Not man alone, but all that roam the wood,  
 Or wing the sky, or roll along the flood,  
 Each loves itself, but not itself alone,  
 Each sex desires alike, till two are one.  
 Nor ends the pleasure with the fierce embrace;  
 They love themselves, a third time, in their race.  
 Thus beast and bird their common charge attend,  
 The mothers nurse it, and the sires defend;  
 The young dismissed to wander earth or air,  
 There stops the instinct, and there ends the care;  
 The link dissolves, each seeks a fresh embrace,  
 Another love succeeds, another race.

POPE.

To return to man, let us consider him as in a state of perfect solitude. Will not the first question be, how came he there? Is not his very existence a proof of a previous society? But let us consider him again as perfectly unconnected, if it be possible, and without any regard to his origin: will he not constantly feel a natural impulse to propagate his species? Will he not incessantly seek a companion to satisfy that desire? And if he find one, is not this the commencement of society?

From this first state of society a third human being is produced, who comes into the world destitute of the least ability to provide for his wants. At the very instant of his birth, he would perish, if Nature had not given his parents a love toward him, an inclination to nourish and support him. The Author of Nature has given milk to his mother for his sustenance, and strength to the father, to protect the mother and the child, and to provide them with subsistence. These are evident proofs of the natural and absolute necessity of society. But from the same father and mother are born several children; and these form a family. These children render to their parents, in their old age, what they received from them in their infancy: they protect them from injuries, and supply them with necessities, when their strength decays, and they are no longer able to provide for themselves. Is this innate love, this attachment, or this instinct, which men and brutes have for the beings to which they have given existence, a circumstance of no consideration? Even the smallest of the feathered tribes have been known to pursue through the air those birds that have robbed them of their young, and to endeavour, at the hazard of their own lives, by incessant efforts and lamentations, to regain them. These very birds remain unconcerned, or hide themselves in their nests, when the bird of prey passes by with other young

ones of the same tribe in his talons. Objects of this kind are common in the country; and they prove, beyond dispute, that property is a natural and inseparable attribute of the existence of every being. The mother, in this instance, seems to cry out, *It is my child.* And is man formed differently? Is he alone born without love, and without interest?

A longer care man's helpless kind demands;  
 The longer care contracts more lasting bands:  
 Reflection, reason, still the ties improve,  
 At once extend the interest, and the love:  
 With choice we fix, with sympathy we burn;  
 Each virtue in each passion takes its turn;  
 And still new needs, new helps, new habits rise,  
 That graft benevolence on charities.  
 Still as one brood, and as another rose,  
 These natural love maintained, habitual those:  
 The last, scarce ripened into perfect man,  
 Saw helpless him from whom their life began:  
 Memory and forecast just returns engage,  
 That pointed back to youth, this on to age;  
 While pleasure, gratitude, and hope combined,  
 Still spread the interest, and preserve the kind.

POPE.

The first natural condition of mankind is unquestionably the union of a male and female. These produce a family, who, from necessity, or, in other words, from parental and filial affection, continue together, and assist each other in procuring food and shelter. This family, like most families in established civil societies, feel their own weakness, and their inability to supply their wants without more powerful resources than their own feeble exertions. When this wandering and defenceless family accidentally meet with another family in the same condition, Nature teaches them to unite for mutual support and protection. The association of two families may be considered as the first formation of a tribe or nation. When a number of tribes happen to unite,



they only become a larger or more numerous nation. A single pair, it is true, if placed in a situation where plenty of food could be procured without much labour, might, in a succession of ages, produce any indefinite number; and this is precisely the situation in which Moses, in his history of the creation, has placed our first parents. In his account of the origin of society, it may be observed, moreover, that the longevity of men, in the first ages of the world, was highly favourable to a speedy population.

In countries thinly peopled with savages, it is extremely probable that societies are formed by the gradual union of families and tribes. The increase of power resulting from mutual assistance, and a thousand other comfortable circumstances, soon contribute to cement more firmly the associated members. Some of the arts of life, beside that of hunting, are occasionally discovered, either by accident, by the ingenuity of individuals, or even from an observation of the labours of the inferior animals in the creation.

See Man from Nature rising slow to Art !  
 To copy Instinct then was Reason's part.  
 See then to Man the voice of Nature spake—  
 ' Go, from the creatures thy instructions take :  
 Learn from the birds what food the thickets yield ;  
 Learn from the beasts the physic of the field ;  
 Thy arts of building from the bee receive ;  
 Learn of the mole to plough, the worm to weave ;  
 Learn of the little nautilus to sail,  
 Spread the thin oar, and catch the driving gale.  
 Here too all forms of social union find,  
 And hence let Reason, late, instruct mankind :  
 Here subterraneous works and cities see ;  
 There towns ærial on the waving tree.  
 Learn each small people's genius, policies,  
 The ant's republic, and the realm of bees ;  
 How those in common all their wealth bestow,  
 And anarchy without confusion know ;

And these for ever, though a monarch reign,  
Their separate cells and properties maintain.  
Mark what unvaried laws preserve each state,  
Laws wise as Nature, and as fixed as Fate.

Great Nature spake; observant Man obeyed;  
Cities were built, societies were made:  
Here rose one little state; another near  
Grew by like means, and joined, through love or fear,

POPE.

The advances from the savage to the civilized state of mankind thus appear to be gradual. This is a very concise view of the origin of society, which has been adopted by most authors, both ancient and modern; for, not to enumerate the various fanciful theories of others, the origin of society must, after all, be derived from its real and only source, Nature herself.

That the associating principle is instinctive hardly requires a proof. An appeal to the feelings of any human being, and to the universal condition of mankind, is sufficient. These feelings, it may be said, are acquired by education and habit. By these causes, it is true, our social feelings are strengthened and confirmed: but their origin is coeval with the existence of the first human mind. Let any man attend to the eyes, the features, and the gestures of a child upon the breast, when another child is presented to it; both instantly, previous to the possibility of instruction or habit, exhibit the most evident expressions of joy. Their eyes sparkle; their features and gestures demonstrate, in the most unequivocal manner, a mutual attachment, and a strong desire of approaching each other, not with a hostile intention, but with an ardent affection, which, in that pure and uncontaminated state of our being, does honour to human nature. When farther advanced, children who are strangers to each other, although their social appetite is equally strong, discover a mutual shyness of approach. This shyness

or modesty, however, is soon conquered by the more powerful instinct of association. They daily mingle and sport together. Their natural affections, which, at that period, are strong, and unbiassed by those selfish and vicious motives which too often conceal and thwart the intentions of Nature, create warm friendships that frequently continue during their lives, and produce the most beneficial and cordial effects. When we thus see with our eyes, that the associating principle appears at a period much more early than many of our other instincts, who will attend to such writers as deny that man is naturally an associating animal?

The advantages which we derive from association are innumerable. Man, from the comparatively great number of instincts with which his mind is endowed, necessarily possesses a portion of the reasoning faculty highly superior to that of any other animal. He alone enjoys the power of expressing and communicating his ideas by articulate and artificial language. This inestimable prerogative is, perhaps, one of the greatest secondary bonds of society, and the greatest source of improvement to the human intellect. Without artificial language, although Nature has bestowed on every animal a mode of expressing its wants and desires, its pleasures and pains, what an humiliating figure would the human species exhibit, even upon the supposition that they did associate! But when association and language are conjoined, the human intellect, in the progress of time, arrives at a high degree of perfection. Society gives rise to virtue, honour, government, subordination, arts, science, order, happiness. All the individuals of a community conduct themselves upon a regulated system.

First gathering men their natural powers combined,  
And formed a Public; to the general good  
Submitting, aiming, and conducting all.

Hence every form of cultivated life  
 In order set, protected, and inspired,  
 Into perfection wrought. Uniting all  
 Society grew numerous, high, polite,  
 And happy. Nurse of art! the city reared,  
 In beauteous pride, her tower-encircled head.  
 Then Commerce brought into the public walk  
 The busy merchant.  
 Then too the pillared dome, magnific, heaved  
 Her ample roof; and Luxury within  
 Poured out her glittering stores; the canvass smooth,  
 With glowing life protuberant, to the view  
 Embodied rose; the statue seemed to breathe,  
 And soften into flesh, beneath the touch  
 Of forming Art.  
 The gift of *Social Labour* these; whate'er  
 Exalts, embellishes, and renders life  
 Delightful.  
 He, the kind source of every gentle art,  
 And all the soft civility of life!  
     Pensive Winter, cheered by him,  
 Sits at the social fire, and happy hears  
 Th' excluded tempest idly rave along;  
 His hardened fingers deck the gaudy Spring;  
 Without him Summer were an arid waste;  
 Nor to th' Autumnal months could e'er transmit  
 Those full, mature, immeasurable stores,  
 That beauteous wave around.

THOMSON.

No. LXIV.

ON THE FEATHERED CREATION,

Videmus  
 Frondiferasque novis avibus canere undique sylvas.  
 LUCRETIVS.

Innumerable songsters, in the freshening shade  
 Of new-sprung leaves, their modulations mix  
 Mellifluous. THOMSON.

THE vocal groves, and the woodland choristers,  
 have been favourite themes with the bard, whom the  
 love of Nature inspires, and whose breast is formed  
 by virtue to a true relish for her charms.

In Milton, the angel Raphael, describing the  
 creation of the world to Adam, forgets not the fea-  
 thered tribes :

Meanwhile the tepid caves, and fens and shores  
 Their brood as numerous hatch, from th' egg that soon  
 Bursting with kindly rupture forth disclosed  
 Their callow young, but feathered soon and fledged  
 They summed their pens, and soaring th' air sublime  
 With clang despised the ground, under a cloud  
 In prospect : there the eagle and the stork  
 On cliffs and cedar tops their eyries build :  
 Part loosely wing the region, part more wise,  
 In common, ranged in figure wedge their way,  
 Intelligent of seasons, and set forth  
 Their aery caravan high over seas  
 Flying, and over lands with mutual wing  
 Easing their flight : so steers the prudent crane  
 Her annual voyage, borne on winds ; the air  
 Floats, as they pass, fanned with unnumbered plumes :  
 From branch to branch the smaller birds with song  
 Solaced the woods, and spread their painted wings  
 Till even, nor then the solemn nightingale  
 Ceased warbling, but all night tuned her soft lays :  
 Others on silver lakes and rivers bathed  
 Their downy breast ; the swan with arched neck



Between her white wings mantling proudly, rows  
 Her state with oary feet; yet oft they quit  
 The dank, and rising on stiff pennons, tower  
 The mid ærial sky. Others on ground  
 Walked firm; the crested cock whose clarion sounds  
 The silent hours, and th' other whose gay train  
 Adorns him, coloured with the florid hue  
 Of rainbows and starry eyes.

Nor can that delightful series of pictures, so truly expressive of the general spirit that pervades the Spring, which Thomson has formed on the variety of circumstances attending 'the passion of the groves,' escape the notice and attention of the most negligent eye. With him we see the gay troops begin to plume the painted wing, and try again the long-forgotten strain. The woods resound with lavish harmony. Attentive to the voice of love, we behold the glossy kind pour forth their little souls in courtship to their mates. Having formed connubial leagues, they retire to their respective haunts, and build their nests with inimitable skill. The parental cares now engage their attention; and with what courage, and with what art, do they employ the varied stratagem, to divert from their tender progeny the rude foot that would molest them! How sweetly too does the poet lament the barbarous art that deprives the soft tribes of liberty and boundless air! How pathetically bemoan the misery of the nightingale, when, returning to her young with loaded bill, she finds a vacant nest, robbed by the hard hand of some unrelenting clown! What a picture does he exhibit, when the feathered youth first attempt to fly; when, the last glad office done, parental love, grown needless, dissolves at once! Nor does he forget the royal eagle, in his towering seat; nor the cawing rook in his airy city; nor the various policy of the mixed domestic kind<sup>1</sup>.

<sup>1</sup> Spring, line 569 to 785.

It is this Mighty Breath, ye sages say,  
 In a powerful language, felt, not heard,  
 Pervades the fowls of heaven; and thro' their breast  
 The arts of love diffuses? What but God!  
 Living God! who, boundless Spirit all,  
 Unremitting Energy, pervades,  
 Sustains, and agitates the whole.  
 ceaseless works *alone*; and yet *alone*  
 Is not to work; with such perfection framed  
 Is complex stupendous scheme of things!  
 tho' concealed to every purer eye  
 Informing Author in his works appears:  
 In thy lovely Spring, in thee, and thy soft scenes,  
 A smiling God is seen; while water, earth,  
 Air, attest his bounty: which exalts  
 Brute creation to this finer thought,  
 Annual melts their undesigning hearts  
 Sweetly thus in tenderness and joy<sup>1</sup>.

It may certainly be ranked among the most  
 perfect creatures in the world. The structure and  
 formation of their bodies, even of their minutest  
 parts is so regular and perfect, as to exhibit the  
 convincing proofs of the wisdom and provi-  
 dence of God. The mechanism that produces the  
 various motions of the winged tribe is wonderful.  
 Anatomical descriptions contained in the treatise  
 on ornithology, or the natural history of birds,  
 are extremely curious and interesting. But, not to  
 enter into a detail that would be too extensive for  
 the limits of this paper, I shall be content, on this  
 subject to quote the observation of M. Vicq d'Azyr,  
 a ingenious French naturalist: 'It is particularly  
 from a close observation, that in comparing the mus-  
 cular bones of birds with those of the human spe-  
 cies the analogies are found to be much greater,  
 more striking, than could have been expected,  
 considering the little resemblance there is between  
 the external forms of these two classes. This evinces  
 a beautiful uniformity that reigns in the great

<sup>1</sup> Spring, line 846, &c.

scheme of nature, and that in orders of being so different. It is also a remarkable proof of final causes, when we consider that the diversities of this otherwise uniform plan, are exactly suited to the nature, structure, and motions, which characterize each class<sup>1</sup>.

The bodies of birds are formed, in every part, with such skill and harmony, as to be perfectly conformable to their manner of living, and to their respective necessities. The stork and heron, which are obliged to seek their food chiefly in the marshes, have long bills, and also very long legs, that they may run into the water without wetting their bodies, and yet reach their prey at a distance. The bills of woodcocks, snipes, and other birds, which hunt for worms in moorish grounds, and which (as Mr. Willoughby observes) live also on the fat unctuous humours they suck out of the earth, are likewise very long; as are also the bills of curlews, and other sea-fowl, that hunt for their food on the sand of the sea-shore. The eagle and vulture, which are rapacious birds, have large wings, strong talons, and sharp-edged beaks. The hooked form of the bills of parrots is of great service to them, in climbing, and catching hold of boughs. The upper bill of this bird is filled with rows of cross bars; and the under bill, which is much shorter, shuts within the upper, and draws against the roof of the mouth; by which means a kind of mastication is effected, before the meat passes into the craw. Ducks, geese, and many others, have long broad bills, to enable them to grope for their food in waters and mud. On the contrary, a thick, short, and sharp-edged bill is as useful to other birds, who have occasion to husk and flay the grain they swallow. The woodpecker's bill is strong, and sharp enough to dig

<sup>1</sup> Hist. de l'Acad. des Sciences à Paris, 1773.

holes, and build in the heart of the hardest timber. The loxia, or crossbill, whose bill is thick and strong, with the tips crossing each other, breaks open fir-cones, apples, and other fruit, to come at the kernels, with such ease, as if the crossing of the bill were for this service. The sea-pies have a long, sharp, narrow bill, compressed sidewise, and in every respect so well adapted to the raising of limpets from the rocks, that Providence seems to have framed it on purpose to enable it to procure that fish, which is its chief, if not its only food<sup>1</sup>. The bills of swallows are slender and sharp-pointed: with a very wide mouth, to enable them the more conveniently to catch insects which are their food, in their swiftest flight.—Moreover, in the bills of all birds, there is an admirable provision for the judging of their food, by certain nerves calculated peculiarly for that purpose; small, and less numerous, in such as have the assistance of another sense, the eye, but large, more numerous, and thickly branched about to the very end of the bill, in such as hunt for their food, out of sight, in water, mud, or under ground.—These observations on the structure of birds, might be extended to many pages: I shall, therefore, only observe further, with respect to their tail, that Willoughby, Ray, and many others, imagine its principal use to be to steer, and to turn the body in the air, as a rudder. But Borelli has demonstrated, that this is the least use of it, and that it is chiefly to assist the bird in ascending and descending in the air, and to obviate the vacillations

<sup>1</sup> The ease with which this bird, by means of its bill, can raise the limpet, is the more wonderful, as this shell-fish adheres so firmly to the rock, as to be separated with great difficulty by a knife. To some that adhered horizontally to the rock, Mr. Reaumur caused a line and weight to be affixed: the least weight capable of moving it, he found to be thirty pounds, and even this it resisted for some time.

of the body and wings: for, with respect to the turning to either side, it is performed by the wings, and inclination of the body, and but very little by the assistance of the tail<sup>1</sup>.

The instinct and industry of birds are in nothing more apparent than in the building of their nests. How regular and admirable are these little edifices, formed of such different materials: collected and arranged with such judgment and labour, and constructed with such elegance and neatness, without any other tools than a beak and two feet.

It wins my admiration,  
To view the structure of that little work,  
A bird's nest. Mark it well within, without,  
No tool had he that wrought, no knife to cut,  
No nail to fix, no bodkin to insert,  
No glue to join: his little beak was all,  
And yet how neatly finished! What nice hand  
With every implement and means of art,  
And twenty years apprenticeship to boot,  
Could make me such another? Fondly then  
We boast of excellence, whose noblest skill  
Instinctive genius foils. VILLAGE CURATE.

Instinctive ingenuity is apparent in all their nests. But the extraordinary subtlety of the long-tailed titmouse deserves particular admiration. With great art she builds her nest with moss, hair, and the webs of spiders, cast out from them when they take their flight<sup>2</sup>, with which the materials are strongly tied together. Having neatly built, and covered her nest with these materials, she thatches it on the top

<sup>1</sup> Borelli de Motu Animalium.

<sup>2</sup> Spiders, which cannot fly, have an admirable faculty to convey themselves with speed and safety, by the help of their webs, or some other artifice, to make their bodies lighter than the air. I have with pleasure often seen them dart out their webs, and sail away by the help thereof. *Derham's Physico-Theology*, book viii. ch. 4.



with the *muscus arboreus ramosus*, or such like broad whitish moss, to keep out rain, and to deceive the eye of any one that might pass near it. The interior part she lines with a great number of small feathers; with so many, that Mr. Derham says he could not but admire how so small a room could hold them; especially, that they could be laid so close and handsomely together, to afford sufficient room for a bird with so long a tail, and so numerous an issue as this bird commonly hath<sup>1</sup>.

Mr. Pennant, in his account of the *taylor bird*, exhibits another instance of the wonderful effect of animal instinct: ‘Had Providence (says he) left the feathered tribe unendued with any particular instinct, the birds of the *torrid zone* would have built their nests in the same unguarded manner as those of Europe; but *there* the lesser species having a certain prescience of the dangers that surround them, and of their own weakness, suspend their nests at the extreme branches of the trees; conscious of inhabiting a clime replete with enemies to them and their young—snakes that twine up the bodies of trees, and apes that are perpetually in search of prey; but, heaven-instructed, they elude the gliding of the one, and the activity of the other. Some form their pensile nest in the shape of a purse, deep and open at top; others with a hole in the side; and others, still more cautious, with an entrance at the very bottom, forming their lodge near the summit.—But the little species here described seem to have greater diffidence than any of the others. It will not trust its nest even to the extremity of the slender twig, but makes one more advance to safety, by fixing it to the leaf itself. It picks up a *dead* leaf, and, surprising to relate, *sews* it to the side of a living one, its slender bill being

<sup>1</sup> Physico-Theology, book iv. ch. 13.

its needle, and its thread some fine fibres : the lining, feathers, gossamer, and down<sup>1</sup>.

The unerring instinct which guides every species of the feathered race, in contriving the most proper habitation for the hatching of their young, instructs them also to repair to the situation the most suitable for them, with respect to their food, their pleasure, and their safety. Hence, the choice of each species is invariably the same. Some repair to the rude thicket; some to the cleft or hollow tree. Some weave their humble nests in the grassy dale, or roughening waste. Others delight in shaggy banks, in woodland solitudes, and unfrequented glooms. Some build in the towering tree, or inaccessible rock; and others prefer the vicinity of man, and take shelter in his chimnies, or in his hospitable eaves.

But who the various nations can declare  
That plough with busy wing the peopled air?  
These cleave the crumbling bark for insect food;  
Those dip the crooked beak in kindred blood;  
Some haunt the rushy moor, the lonely woods;  
Some bathe their silver plumage in the floods;  
Some fly to man, his household gods implore,  
And gather round his hospitable door,  
Wait the known call, and find protection there  
From all the lesser tyrants of the air.  
The tawny eagle seats his callow brood  
High on the cliff, and feasts his young with blood.  
On Snowdon's rocks, or Orkney's wide domain,  
Whose beetling cliffs o'erhang the western main,

<sup>1</sup> Mr. Pennant has given a picture of this extraordinary piece of architecture : the *live* leaf, which serves for its basis, being that of the mango-tree, with the nest affixed to it, and the birds projecting their little heads above the entrance of their pendent habitations. He informs us also, that one of these curious nests is preserved in the British Museum. The colour of these ingenious *flying taylor*s is a light yellow; its eggs are white; its length is three inches; its weight only three sixteenths of an ounce; so that the materials of the nest, and its own size, are not likely to draw down a habitation that depends on so slight a tenure. *Indian Zoology*, part i.

The royal bird his lonely kingdom forms,  
Amid the gathering clouds and sullen storms :  
Through the wide waste of air he darts his sight,  
And holds his sounding pinions poised for flight ;  
With cruel eye premeditates the war,  
And marks his destined victim from afar<sup>1</sup> :  
Descending in a whirlwind to the ground,  
His pinions like the rush of waters sound ;  
The fairest of the fold he bears away,  
And to his nest compels the struggling prey.

BARBAULD.

Although the sparrows, in general, construct their nests under the tiles of houses, or in holes in the walls, some build them on the tops of trees. This difference of situation affords them an opportunity of exhibiting a singular instance of instinctive sagacity. In the nests built on trees they form an artificial roof, which covers the nest, and prevents the entrance of rain ; forming, at the same time, an opening under it : on the contrary, when they build under cover, they abstain from this work of supererogation. Instinct (says the celebrated Buffon) is manifested in this case, in a manner nearly analogous to reason ; as it supposes, at least, the comparing together of two ideas. In this little race, there is a diversity of manners, and a more varied and perfected instinct than in most other birds. This improvement he ascribes to their frequenting human society. They are in part domesticated ; but without being subjected to it, or losing their independence. From this society they draw whatever suits their convenience, and in it they acquire that subtlety, circumspection, and improvement of the instinctive faculty, which is exhibited in the great va-

<sup>1</sup> Doth the eagle mount up at thy command, and make her nest on high ? She dwelleth and abideth on the rock, upon the crag of the rock, and the strong place : thence she seeketh the prey, and her eyes behold afar off. *Job xxxix.* 27—29.

riety of their habits, relative to different situations, seasons, and other circumstances<sup>1</sup>.

I might here extend my observations to the *incubation* and *migration* of birds: but these shall be noticed in some future pages<sup>2</sup>. I shall only add, at present, that from the consideration of the providential care so evidently manifested in the preservation of the aërial tribes, the divine Teacher of our holy religion has drawn an argument to prevent our sinking into anxiety and despondence, and to induce us to rely with filial confidence and piety in the goodness of our heavenly Parent: ‘*Behold the fowls of the air: for they sow not, neither do they reap, nor gather into barns; yet our heavenly Father feedeth them. Are ye not much better than they?*’

Behold, and look away your low despair!  
 See the light tenants of the barren air:  
 To them, nor stores, nor granaries belong;  
 Nought, but the woodland, and the pleasing song;  
 Yet, your kind heavenly Father bends his eye  
 On the least wing that flits along the sky.  
 To him they sing when spring renews the plain,  
 To him they cry in winter's pinching reign;  
 Nor is their music, or their plaint in vain:  
 He hears the gay, and the distressful call,  
 And with unsparing bounty fills them all.  
 If, ceaseless, then the fowls of heaven he feeds,  
 If o'er the fields such lucid robes he spreads;  
 Will he not care for you, ye faithless, say?  
 Is he unwise? Or, are ye less than they?    THOMSON.

<sup>1</sup> Histoire Naturelle des Oiseaux, tome iii.

<sup>2</sup> The two succeeding Numbers are on the subject of *migration*; in No. LXVIII, On the Instinct of Brutes, are some observations on the *uniformity* of the nests of the different species of birds; and in No. LXX, On the Habitations of Animals, are some further observations on the *nidification* and *incubation* of several birds.

No. LXV.

ON THE MIGRATION OF BIRDS.

*Yes, the stork in the heaven knoweth her appointed times ;  
the turtle, and the crane, and the swallow, observe the  
e of their coming.*

JEREMIAH:

Who bid the stork, Columbus-like, explore  
Heavens not his own, and worlds unknown before ?  
Who calls the council, states the certain day ?  
Who forms the phalanx, and who points the way ?

POPE.

THE migration of birds has been justly con-  
sidered as one of the most wonderful instincts of  
nature. Milton, in the passage I quoted in my  
preceding paper, styles the feathered race, thus dis-  
tinctly taught, ‘ intelligent of seasons ;’ and the ve-  
nerable prophet above adduces this instinctive and  
variable observation of their appointed times, as a  
circumstance of reproach to the chosen people of  
Israel, who, although taught by reason and religion,  
saw not the judgment of the Lord.’

The appearance and disappearance of the birds  
in season, particularly in the Hebrides, or Western  
islands of Scotland, has not been disregarded by our  
poets. Thus Mallet speaks of the birds that  
usually transmigrate to St. Kilda, the most remote  
and unfrequented of all those islands :

But, high above, the season full exerts  
Its vernal force in yonder peopled rocks,  
To whose wild solitude, from worlds unknown,  
The birds of passage transmigrating come,  
Unnumbered colonies of foreign wing,  
At Nature’s summons, their aerial state  
Annual to found : and in bold voyage steer,  
O’er this wide ocean, through yon pathless sky,



One certain flight to one appointed shore :  
 By Heaven's directive spirit, here to raise  
 Their temporary realm ; and form secure,  
 Where food awaits them copious from the wave,  
 And shelter from the rock, their nuptial leagues :  
 Each tribe apart, and all on tasks of love,  
 To hatch the pregnant egg, to rear and guard  
 Their helpless infants, piously intent.

Their appearance in the same islands is thus noticed  
 by Thomson :

Where the northern ocean, in vast whirls,  
 Boils round the naked melancholy isles  
 Of farthest Thulé, and th' Atlantic surge  
 Pours in among the stormy Hebrides ;  
 Who can recount what transmigrations there  
 Are annual made ? What nations come and go ?  
 And how the living clouds on clouds arise ?  
 Infinite wings ! till all the plume-dark air,  
 And rude resounding shore, are one wild cry.

And their disappearance from the same scenes is  
 thus described by Mrs. Barbauld :

When winter bites upon the naked plain,  
 Nor food nor shelter in the groves remain,  
 By instinct led, a firm united band,  
 As marshalled by some skilful general's hand,  
 The congregated nations wing their way  
 In dusky columns o'er the trackless sea ;  
 In clouds unnumbered annual hover o'er  
 The craggy Bass, or Kilda's utmost shore :  
 Thence spread their sails to meet the southern wind,  
 And leave the gathering tempest far behind,  
 Pursue the circling sun's indulgent ray,  
 Course the swift seasons, and o'ertake the day.

The migration of birds, which is common to the  
 quail, the stork, the crane, the fieldfare, the wood  
 cock, the cuckoo, the martin, the swallow, and  
 various others, is, indeed, a very curious article of  
 natural history, and furnishes a very striking in-  
 stance of a powerful instinct impressed by t

Creator. Dr. Derham observes two circumstances remarkable in this migration: the first, that these untaught, unthinking creatures, should know the proper times for their passage, when to come, and when to go; as also, that some should come when others go. No doubt, the temperature of the air as to heat and cold, and their natural propensity to breed their young, are the great incentives to these creatures to change their habitations. But why should they at all change their habitations? And why is not some certain place to be found, in all the terraqueous globe, that, all the year round, can afford them convenient food and habitation?—The second remarkable circumstance is, that they should know which way to steer their course, and whither to go. What instinct is it that can induce a poor foolish bird to venture over vast tracts of land and sea? If it be said, that by their high ascents into the air, they can see across the seas; yet what shall instruct or persuade them, that another land is more proper for their purpose than this? That Great Britain, for instance, should afford them better accommodation than Egypt, the Canaries, Spain, or any of the other intermediate countries<sup>1</sup>?

The birds of passage, moreover, are all peculiarly accommodated, by the structure of their parts, for long flights; and it is remarked, that, in their migrations, they observe a wonderful order and polity: they fly in troops, and steer their course, without the aid of a compass, to vast unknown regions. The flight of the wild geese, in a wedge-like figure, has been often observed; to which it is added, by the natural historian of Norway, that the three foremost, who are the soonest tired, retreat behind, and are relieved by others, who are again succeeded by the rest in order<sup>2</sup>. But this circumstance has been ob-

<sup>1</sup> Physico-Theology, book vii. chap. 3.

<sup>2</sup> *Bp. Pontoppidan.*

served, many ages before, by Pliny, who describes certain birds of passage flying in the form of a wedge, and spreading wider and wider; those behind resting upon those before, till the leaders, being tired, are, in their turn, received into the rear. 'Wild ducks and cranes (says the abbé de la Pluche) fly at the approach of winter, in quest of more favourable climates. They all assemble, at a certain day, like swallows and quails. They decamp at the same time, and it is very agreeable to observe their flight. They generally range themselves in a long column like an I, or in two lines united in a point like a V reversed.' And thus, as Milton says,

Ranged in figure wedge their way.

'The duck or quail that forms the point (adds the abbé) cuts the air, and facilitates a passage to those that follow: but he is charged with this commission only for a certain time, at the conclusion of which he wheels into the rear, and another takes his post<sup>2</sup>. And thus again, as Milton observes,

With mutual wing  
Easing their flight.

It has been observed of the storks, that, for about the space of a fortnight before they pass from one country to another, they constantly resort together, from all the circumjacent parts, to a certain plain, and there forming themselves once every day into a *dou-wanne* (according to the phrase of the people) are said to determine the exact time of their departure, and the places of their future abode<sup>3</sup>.

<sup>1</sup> A tergo sensim dilatante se cuneo porrigitur agmen, largè-  
que impellenti præ betu auræ. Colla imponunt præcenden-  
tibus: fessos duces ad terga recipiunt. Nat. Hist. l. x.  
sect. 32.

<sup>2</sup> Spectacle de la Nature, dial. ix.

<sup>3</sup> Shaw's Travels, p. 428. fol.

Where the Rhine loses its majestic force  
In Belgian plains, won from the raging deep,  
By diligence amazing, and the strong  
Unconquerable hand of Liberty,  
The stork assembly meets ; for many a day,  
Consulting, deep, and various, ere they take  
Their arduous voyage thro' the liquid sky.  
And now, their route designed, their leaders chose,  
Their tribes adjusted, cleaned their vigorous wings ;  
And many a circle, many a short essay,  
Wheeled round and round, in congregation full  
The figured flight ascends ; and riding high  
The aerial billows, mixes with the clouds.

THOMSON.

Mr. Biberg, an ingenious naturalist of Sweden, has observed, that ' the starling, finding, after the middle of summer, that worms are less plentiful in that country, goes annually into Scania, Germany, and Denmark. The female chaffinches, every winter, about Michaelmas, go in flocks to Holland ; but as the males stay in Sweden, the females come back next spring, except such as choose to breed no more. In the same manner, the female Carolina yellow-hammer, in the month of September, while the rice on which she feeds is laid up in granaries, goes toward the south, and returns in the spring to seek her mate. Our aquatic birds (continues he) are forced by necessity to fly toward the south every autumn, before the water is frozen. Thus we know, that the lakes of Poland and Lithuania are filled with swans and geese every autumn, at which time they go in great flocks, along many rivers, as far as the Euxine Sea. But in the beginning of spring, as soon as the heat of the sun molests them, they return back, and go again to the northern ponds and lakes, in order to lay their eggs. For there, and especially in Lapland, there is a vast abundance of gnats, which afford them excellent nourishment, as all of this kind live in the water before they get

their wings.'—Mr. Biberg proceeds to enumerate many other birds that migrate to different regions; and he then adds: 'By these migrations, birds become useful to many different countries, and are distributed over almost all the globe; and I cannot here forbear expressing my admiration, that all of them exactly observe the times of coming and going, and that they never mistake their way<sup>1</sup>.'

The principal food of the birds of passage, while in Great Britain, is the fruit of the white thorn, or haws, which hang on our hedges in winter in prodigious plenty; but where they breed, and seem to be most at ease, as in Sweden, &c. there are no haws; nor indeed in many of the countries through which they journey on their way: so that it is evident they change their food in their passage.

The manner in which the birds of passage journey to their southern abodes is supposed to vary, according to the different structure of their bodies, and their power of supporting themselves in the air. The birds with short wings, such as the redstart, blackcap, &c. though they are incapable of such long flights as the swallow, or of flying with such celerity, yet may pass to less distant places, and by slower movements. Swallows and cuckoos may perform their passage in a very short time; but there is for them no necessity for speed, since every day's passage affords them an increase of warmth, and a continuance of food.

Swallows are often observed, in innumerable flocks, on churches, rocks, and trees, previous to their departure hence; and Mr. Collinson proves their return here, perhaps in equal numbers, by two curious relations of undoubted credit; the one communicated to him by Mr. Wright, the master of a

<sup>1</sup> Biberg On the Economy of Nature, in Stillingfleet's Miscellaneous Tracts.



ship, and the other by admiral Sir Charles Wager. — 'Returning home (says Sir Charles) in the spring of the year, as I came into soundings in our channel, a great flock of swallows came and settled on my rigging; every rope was covered; they hung on one another like a swarm of bees; the decks and carving were filled with them. They seemed almost famished and spent, and were only feathers and bones; but, being recruited with a night's rest, they took their flight in the morning.'—This apparent fatigue proves, that they must have had a long journey, considering the amazing swiftness of these birds; so that, in all probability, they had crossed the Atlantic ocean, and were returning from the shores of Senegal, or other parts of Africa.—But the state of the swallow-tribes, when they are no longer seen in our northern regions, has given rise to a curious controverted question among naturalists, of which I shall treat in my next paper. In the mean time, my readers, I am persuaded, will be pleased with the following beautiful poetical welcome to these birds, on their re-appearance in the Spring, by the contemporary and friend of Shenstone and Collins:

At length the winter's surly blasts are o'er;  
 Arrayed in smiles the lovely spring returns:  
 Health to the breeze unbars the screaming door,  
 And every breast with heat celestial burns.

And see, my Delia, see o'er yonder stream,  
 Where on the sunny bank the lambskins play;  
 Alike attracted to th' enliv'ning gleam,  
 The stranger-swallows take their wonted way.

Welcome, ye gentle tribe, your sports pursue,  
 Welcome again to Delia, and to me:  
 Your peaceful councils on my roof renew,  
 And plan your settlements from danger free.

No tempest on my shed its fury pours,  
 My frugal hearth no noxious blast supplies;

Go, wand'ers, go, repair your sooty bowers,  
Think, on no hostile roof my chimnies rise.

Again I'll listen to your grave debates,  
I'll think I hear your various maxims told,  
Your numbers, leaders, policies, and states,  
Your limits settled, and your tribes enrolled.

I'll think I hear you tell of distant lands,  
What insect-nations rise from Egypt's mud,  
What painted swarms subsist on Libya's sands,  
What mild Euphrates yields, and Ganges' flood.

Thrice happy race! whom Nature's call invites  
To travel o'er her realms with active wing,  
To taste her choicest stores, her best delights,  
The summer's radiance, and the sweets of spring:

While we are doomed to bear the restless change  
Of shifting seasons, vapours dank, or dry,  
Forbid, like you, to milder climes to range,  
When wintry clouds deform the troubled sky.

But know the period to your joys assigned!  
Know ruin hovers o'er this earthly ball;  
Certain as fate, and sudden as the wind,  
Its secret adamant prop shall fall.

Yet when your short-lived summers shine no more,  
My patient mind, sworn foe to vice's way,  
Sustained on lighter wings than yours, shall soar  
To fairer realms beneath a brighter ray:

To plain etherial, and Elysian bowers,  
Where wintry storms no rude access obtain,  
Where blasts no lightning, and no thunder low'rs,  
But spring and joy unchanged for ever reign.

JAGO.

NO. LXVI.

FURTHER REFLECTIONS ON THE MIGRATION OF BIRDS.

Where do the cranes, or winding swallows, go?  
 Fearful of gathering winds and falling snow?  
 If into rocks, or hollow trees, they creep,  
 In temporary death confined to sleep;  
 Or, conscious of the coming evil, fly  
 To milder regions and a southern sky?

PRIOR.

*To the SWALLOW.*

Gentle Herald of the Spring,  
 Gliding swift on wand'ring wing,  
 Say from what distant climes returned,  
 Thou view'st Britannia's realm again,  
 And, skimming o'er the primrose plain,  
 Pursu'st, in ecstasy, thine airy flight,  
 Oft gazing with increased delight  
 On her fair fields, with softest verdure crowned,  
 While April spreads his chequered gems around?

Com'st thou from Afric's sultry waste,  
 To shun her summer's scorching heat;  
 Where, fiercely gleaming o'er the blasted heath,  
 The dry Harimaton breathes the gale of death?

Or com'st thou from some secret cave,  
 Waked from thy long repose,  
 Where wint'ry winds around thee blew,  
 And fell the driving snows;  
 Where storms unheeded rent the troubled air,  
 While ev'ry field was bleak, and ev'ry tree was bare?

Or sunk beneath the whelming tide,  
 Could thy feathered form reside,  
 And, strange to tell! by secret charms,  
 While Naiads waved their circling arms,  
 In liquid crystal pass the wint'ry gloom,  
 Till earth again disgorged her vernal bloom?

DR. SHAW.

I INTIMATED, in my former paper, that the state of the swallow-tribes, when they are no longer seen in our regions, has given rise to a controverted question in natural history. The poets, as well as the philosophers, seem to be divided on the subject. Thus Anacreon, as paraphrased by Cowley, addresses the swallow :

In thy undiscovered nest  
Thou dost all the winter rest,  
And drest o'er thy summer joys,  
Free from the stormy season's noise.

And Thomson, in noticing their disappearance in autumn, speaks with the same uncertainty on the subject, as do the poets in my motto :

When Autumn scatters his departing gleams,  
Warned of approaching Winter, gathered, play  
The swallow-people ; and tossed wide around,  
O'er the calm sky, in convulsion swift,  
The feathered eddy floats : rejoicing once,  
Ere to their wintry slumbers they retire ;  
In clusters clung, beneath the mould'ring bank,  
And where, unpierced by frost, the cavern sweats.  
Or rather into warmer climes conveyed,  
With other kindred birds of season, there  
They twitter cheerful, till the vernal months  
Invite them welcome back : for, thronging, now  
Innumerable wings are in commotion all.

Naturalists, as I have before observed, are likewise much divided in their opinion concerning the periodical appearance and disappearance of swallows. Some assert, that they remove from climate to climate, at those particular seasons when winged insects, their natural food, fail in one country, and are plentiful in another, where they likewise find a temperature of air better suited to their constitution. In support of this opinion we have the testimony

of Sir Charles Wager, mentioned in my preceding paper, and of M. Adanson, who, in the account of his voyage, informs us, that, about fifty leagues from the coast of Senegal, four swallows settled upon the ship, on the sixth day of October; that these birds were taken; and that he knew them to be the true swallow of Europe, which he conjectures were then returning to the coast of Africa. But Mr. Daines Barrington, in a curious essay on this subject<sup>1</sup>, has adduced many arguments and facts, to prove, that no birds, however strong and swift in their flight, can possibly fly over such large tracks of the ocean as has been commonly supposed. He is of opinion, therefore, that the swallows mentioned by M. Adanson, instead of being on their passage from Europe, were only fluttering from the Cape de Verde Islands to the continent of Africa; a much nearer flight, but to which they seemed to be unequal, as they were obliged, from fatigue, to alight upon the ship, and fall into the hands of the sailors. And Mr. Kalm, another advocate for the torpidity of swallows during the winter, having remarked, however, that he himself had met with them 920 miles from any land; Mr. Barrington endeavours to explain these, and similar facts, by supposing, that birds discovered in such situations, instead of attempting to cross large branches of the ocean, have been forcibly driven from some coast by storms, and that they would naturally perch upon the first vessel they could see.

In a word, Mr. Barrington is further of opinion, with some other naturalists, that the swallows do not leave this island at the end of autumn, but that they lie in a torpid state, till the beginning of summer, in the banks of rivers, the hollows of decayed trees, the recesses of old buildings, the holes of sand banks,

<sup>1</sup> Phil. Trans. vol. lxii. p. 265.



and in similar situations. Among other facts, Mr. Barrington communicated one to Mr. Pennant: 'That numbers of swallows have been found in old dry walls, and in sand hills, near the seat of the late Lord Belhaven in East Lothian; not once only, but from year to year; and that, when they were exposed to the warmth of a fire, they revived.'

These, and other facts of the same kind, are allowed to be incontrovertible; and Mr. Pennant, in particular, infers from them, 'that we must divide our belief relative to these two so different opinions, and conclude, that one part of the swallow-tribe *migrate*, and that others have their winter quarters *near home*'<sup>1</sup>.

But there are still more wonderful facts related. Mr. Kalm remarks, that swallows appear in the Jerseys about the beginning of April; that, on their first arrival they are wet, because they have just emerged from the sea or lakes, at the bottom of which they had remained in a torpid state during the whole winter<sup>2</sup>. Other naturalists have asserted, that swallows pass the winter immersed under the ice, at the bottom of lakes, or beneath the waters of the sea. Olaus Magnus, archbishop of Upsal, seems to have been the first who adopted this opinion. He informs us, that swallows are found in great clusters at the bottoms of the northern lakes, with mouth to mouth, wing to wing, foot to foot, and that in autumn they creep down the reeds to their subaqueous retreats<sup>3</sup>. In other instances, Mr. Pennant remarks, the good archbishop did not want credulity. But the submersion of the swallows under water does not rest upon his testimony alone. Klein asserts the same; and gives the following ac-

<sup>1</sup> British Zoology, vol. ii. p. 250, 8vo edit.

<sup>2</sup> Voyage, tome i. p. 24.

<sup>3</sup> Derham's Physico Theol.

ment of their manner of retiring, which he collected from some countrymen: 'They asserted, that the wallows sometimes assembled in numbers on a reed till it broke, and sunk them to the bottom; that their immersion was preceded by a kind of dirge, which lasted more than a quarter of an hour; that others waited, laid hold of a straw with their bills and lunged down in society; that others, by clinging together with their feet, formed a large mass, and in this manner committed themselves to the deep<sup>1</sup>.'—Bishop Pontoppidan asserts, that clusters of swallows in their torpid winter state, have sometimes been found by fishermen, among reeds and bushes in lakes; and he charges Mr. Edwards with having, in his *Natural History of Birds*, groundlessly contradicted this incontestible truth<sup>2</sup>.—And Mr. Heerens, a celebrated Dutch naturalist, in a Latin poem on the Birds of Friesland, speaks in positive terms of the torpid state, and submersion, of the wallows:

Conditur ante hiemem, semestri obnoxia somno,  
 Conditur, et variis condita visa locis;  
 Est, ubi se scopulis per frigora sopit, et antris;  
 Est ubi, structuris rudibusque latet.  
 Connexus, quandoque vides, rostra indita rostris.  
 Est quoque sola, suo quæ jacet orba viro.  
 Res est mira, latet gelidis quandoque sub undis,  
 Ut prope cognatam piscibus esse putes.

Ere winter his somniferous power exerts  
 Six dreary months, the swallow-tribes are seen  
 In various haunts concealed; in rocks, and caves,  
 And structures rude, by cold benumbed, asleep;  
 Bill within bill inserted, clust'ring thick:  
 Or solitary some, of mate bereft.  
 But, wonderful to tell! some lie immersed,  
 Inanimate, beneath the frigid waves,  
 As if a species of the finny kinds.

<sup>1</sup> Klein Prod. Hist. Avium, p. 205.

<sup>2</sup> Natural History of Norway.

Mr. Heerkens, after reciting many instances, and producing in his notes several authorities, of swallows having been found in a torpid state, proceeds, in his poem, to describe very minutely, their ascent out of the water: The drowsy birds appear on the shore, as if unconscious still of life. Some inhale the soft breeze, like one of the finny tribe exiled from its stream. Some begin to adjust their dishevelled wings. Others, almost revived, essay, with busy bill, to assist their aged companions. All, at length, restored to the unrestrained use of their wings, range, in numerous flights, the aerial way<sup>1</sup>.

Two reasons have been adduced to prove this supposed submersion of swallows impossible. 'In the first place (says Mr. Smellie) no land animal can exist so long without some degree of respiration. The otter, the seal, and waterfowls of all kinds, when confined under the ice, or entangled in nets, soon perish; yet it is well known, that animals of this kind can remain much longer under water than those which are destitute of that peculiar structure of the heart which is necessary for any considerable residence beneath that penetrating element. Mr. John Hunter, in a letter to Mr. Pennant, informs us, 'That he had dissected many swallows, but found nothing in them different from other birds as to the organs of respiration: That all those animals which he had dissected of the class that sleep during the winter, such as lizards, frogs, &c. had a very different conformation as to those organs: That all those animals, he believes, do breathe in their torpid state; and, as far as his experience reaches, he knows they do; and that, therefore, he esteems it a very wild opinion, that terrestrial animals can remain any long time under water without drown.

<sup>1</sup> Ger. Nicolai Heerkens Groningani *Aves Frisicæ*, 8vo, Rotterdam 1787.

ing.'—Another argument against their submersion arises from the specific gravity of the animals themselves. Of all birds, the swallow-tribes are perhaps the lightest. Their plumage, and the comparative smallness of their weight, indicate that Nature destined them to be almost perpetually on the wing in quest of food. From this specific lightness, the submersion of swallows, and their continuing for months under water, amount to a physical impossibility. Even waterfowls, when they wish to dive, are obliged to rise and plunge with considerable exertion, in order to overcome the resistance of the water. Klein's idea of swallows employing reeds and straws as means of submersion is rather ludicrous; for these light substances, instead of being proper instruments for assisting them to reach the bottom, would infallibly contribute to support them on the surface, and prevent the very object of their intention. Besides, admitting the possibility of their reaching the bottom of lakes and seas, and supposing they could exist for several months without respiration, what would be the consequence? The whole would soon be devoured by otters, seals, and fishes of various kinds. Nature is always anxious for the preservation of its species. But, if the swallow-tribes were destined to remain torpid, during the winter months, at the bottom of lakes and seas, she would act in opposition to her own intentions; for, in a season or two, the whole genus would be annihilated<sup>1</sup>.

This reasoning is very ingenious; but, on the other hand, the facts related above are very stubborn; and the celebrated Buffon does not hesitate to yield to the force of such strong and concurrent evidence. He had procured some chimney swallows, and kept them some time in an icehouse, in order to

<sup>1</sup> Philosophy of Natural History, p. 481.

ascertain whether *they* were of the torpid kind; and he thus relates the result of his experiment: 'None of them fell into the torpid state: the greater part died, and not one of them revived by being moved into the warmth of the sun. Those that had not long suffered the cold of the icehouse had all their movements, and went out briskly. From these experiments I thought I might conclude, that this species of the swallow was not liable to that state of torpor and insensibility, which supposes, notwithstanding, and very necessarily, the fact of its remaining at the bottom of the water during the winter. Having had recourse, moreover, to the most creditable travellers, I found them agreed as to the passage of swallows over the Mediterranean. And M. Adanson has positively assured me, that during the long stay he made in Senegal, he observed the long-tailed swallow, the same with the chimney swallow we are now speaking of, arrive constantly in Senegal about the time it leaves France, and as constantly leave Senegal in the spring. It cannot, therefore, be doubted, that this species of the swallow passes from Europe into Africa in the autumn, and from Africa to Europe in the spring; of consequence it neither sleeps nor hides itself in holes, nor plunges into the water on the approach of winter. There is, besides, another well authenticated fact, which comes in proof here, and shows that this swallow is not reduced to a torpid state by cold, which it can bear to a certain degree; and if that degree is exceeded, it dies: for if we observe these birds toward the end of the warm season, we shall see them, a little before their departure, flying together in families, the father, the mother, and the young brood. Afterward several families unite, and form themselves into flocks more or less numerous in proportion as the time of their departure draws near. At last they go altogether, three or four days before the end of September, or



about the beginning of October. Still, however, some remain, and do not set off till a week, a fortnight, or three weeks after the rest: and some too there are which do not go at all, but stay and perish under the first rigours of the cold. These swallows that delay their flight, or never undertake it, are such as find their young too weak to follow them; such as have had the misfortune to have their nests destroyed after laying, and have been obliged to rebuild them a second or a third time. They stay for the love of their little ones, and choose rather to endure the rigour of the season than to abandon their offspring. Thus they remain sometime after the rest for the purpose of taking their young with them: and if they are unable to carry them off in the end, they perish with them.

These facts then plainly demonstrate (concludes M. Buffon) that the chimney swallows pass successively and alternately from our climate to another that is warmer; that they spend their summer here, and their winter there; and of consequence never fall into a state of insensibility. But, on the other hand, what have we to oppose to the precise testimony of those who, on the approach of winter, have seen these swallows in troops throw themselves into the water; nay, not only this, but have seen them taken out in nests from beneath the ice? What answer shall we make to those who have beheld them in the torpid state, and seen them gradually recover motion and life, when they were brought into the warmth, and moved cautiously toward a fire? I know but of one means of reconciling these facts. We must suppose that the sleeping and the travelling swallow are of different species, though the difference, for want of attention, has not been observed<sup>1</sup>.

Thus this great philosopher concurs with Mr.

<sup>1</sup> *Histoire Naturelle des Oiseaux*, tome i.

Pennant, in his solution, already mentioned, of the difficulty, by supposing two species—the *migrating* and the *sleeping* swallow. With respect to the principal objects of this wonderful instinct, that teaches such various kinds of the feathered race to migrate to different countries, it is obvious from what has already been said, that they are food, temperature of air, and convenient situations, for breeding<sup>1</sup>. I shall, therefore, conclude this paper with the following beautiful stanzas, from an elegy by Mr. Jago, on their disappearance from this country :

Through sacred prescience, well they know  
     The near approach of elemental strife ;  
 The blustry tempest, and the chilling snow,  
     With every want and scourge of tender life !

Thus taught, they meditate a speedy flight ;  
     For this ev'n now they prune their vig'rous wing ;  
 For this consult, advise, prepare, excite,  
     And prove their strength in many an airy ring.

No sorrow loads their breast, or swells their eye,  
     To quit their friendly haunts, or native home ;  
 Nor fear they, launching on the boundless sky,  
     In search of future settlements to roam.

They feel a power, an impulse all divine !  
     That warns them hence ; they feel it, and obey ;  
 To this direction all their cares resign,  
     Unknown their destined stage, unmarked their way !

Well fare your flight ! ye mild domestic race !  
     Oh ! for your wings to travel with the sun !  
 Health brace your nerves, and zephyrs aid your pace,  
     'Till your long voyage happily be done !

See, Delia, on my roof your guests to-day ;  
     To-morrow on my roof your guests no more !  
 Ere yet 'tis night, with haste they wing away,  
     To-morrow lands them on some safer shore.

<sup>1</sup> See an ingenious little work by *Mr. Forster, on the Brutal Retreat of the Swallow*, third edition, for more on this subject.

How just the moral in this scene conveyed !  
 And what without a moral would we read ?  
 Then mark what Damon tells his gentle maid,  
 And with *his* lesson register the deed.

'Tis thus life's cheerful seasons roll away ;  
 Thus threatens the winter of inclement age ;  
 Our time of action but a summer's day :  
 And earth's frail orb the sadly-varied stage !

And does no power its friendly aid dispense,  
 Nor give *us* tidings of some happier clime ?  
 Find *we* no guide in gracious Providence  
 Beyond the stroke of death, the verge of time ?

Yes, yes, the sacred oracles we hear,  
 That point the path to realms of endless day ;  
 That bid our hearts, nor death, nor anguish fear,  
*This* future transport, *that* to life the way.

Then let us timely for our flight prepare,  
 And form the soul for her divine abode ;  
 Obey the call, and trust the Leader's care  
 To bring us safe through virtue's paths to God.

Let no fond love for earth exact a sigh,  
 No doubts divert our steady steps aside ;  
 Nor let us long to live, nor dread to die ;  
 Heav'n is our hope, and Providence our guide.

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## NO. LXVII.

### ON MIGRATION IN GENERAL.

Atque alio patriam quærunt sub sole jacentem.

VIRGIL.

Regions they seek beneath another sun.

MIGRATION is generally supposed to be peculiar to the feathered tribe ; but this is a limited idea, which has originated from inattention to the economy of Nature. Birds migrate with a view to

remedy the inconveniencies of their present situation, and to acquire a more commodious station with regard to food, temperature, propagation, and shelter; but, from similar motives, men, sometimes in amazing multitudes, have migrated from north to south, displaced the native inhabitants, and fixed establishments in more comfortable climates than those which they had relinquished; and these, in their turn, have fallen victims to fresh and barbarous emigrants. Among the inhabitants of the more northern nations, as Norway, Sweden, &c. notwithstanding a very strong attachment to their native countries, there seems to be a natural or instinctive propensity to migrate. Poverty, rigour of climate, curiosity, ambition, false representations of interested individuals, the oppression of feudal barons, and similar circumstances, have given rise to great emigrations of the human species. But it is worthy of remark, that the emigrations from south to north, except from the love of conquest in ambitious nations, are so rare, that the instinct seems hardly to exist in those more fortunate climates. Curiosity is a general instinctive principle, which operates strongly in the youthful periods of life, and stimulates every man to visit places that are distant from his ordinary residence. This innate desire is influenced by the relations of travellers, and by many other incentives of a more interested kind. Without the principle of migration, mankind, it is probable, would never have been so universally diffused over the surface of the earth. It is counterbalanced, however, by attachment to those countries which give us birth, a principle still more powerful and efficient. Love of our native country is so strong, that, after gratifying the migrating principle, almost every man feels a longing desire to return.

Savages, as long as their store of food remains unexhausted, continue in a listless inactive state, and

seem not to be prompted by any motives of curiosity. They have no conception of a man's walking either for amusement or exercise. But, when their provisions begin to fail, an astonishing reverse takes place. They then rouse, as from a profound sleep. In quest of wild beasts, birds, and fishes, they migrate to immense distances, exert the greatest feats of activity, and endure incredible hardships and fatigue. After acquiring a store of provisions, they return to their wonted haunts, and remain inactive till their food begins again to fail.

Quadrupeds likewise perform partial migrations. At the approach of winter, the stag, the reindeer, and the roebuck, leave the tops of the lofty mountains and come down to the plains and copses. Their chief objects, in these flittings, are food and shelter. When summer commences they are harassed with different species of winged insects, and to avoid these enemies, they regain the summits of the mountains, where the cold, and the height of the situation, protect them from their attacks. In Norway, and the more northern regions of Europe, the oxen, during the winter, migrate to the shores of the sea, where they feed upon sea plants and the bones of fish; and bishop Pontoppidan remarks, that the cattle know by instinct when the tide retires, and leaves these articles of food upon the shore. In Orkney and Shetland, the sheep, for the same purposes, uniformly repair to the shore, in winter, at the ebbing of the tides. Rats, particularly those of the northern regions of Europe, appear, from time to time, in such myriads, that the inhabitants of Norway and Lapland imagine the animals fall from heaven. The celebrated Linné, who paid great attention to the economy of these migrating rats, remarked, that they appeared in Sweden periodically every eighteen or twenty years. When about to migrate, they leave their wonted abodes, and assemble together in in-



conceivable numbers. In the course of their journey they make tracks in the earth of two inches in depth; and these tracks sometimes occupy a breadth of several fathoms. What is singular, the rats in their march uniformly pursue a straight line, unless they are forced to turn aside by some insurmountable obstacle. If they meet with a rock, they first try to pierce it, and, after discovering the attempt to be impracticable, they go round it, and then resume the straight line. Even a lake does not interrupt their passage; for they either traverse it in a straight line, or perish in the attempt; and if they meet with a bark or other vessel, they do not alter their directions, but climb up the one side of it and descend by the other.

Frogs, immediately after their transformation from the tadpole state, leave the water and migrate to the meadow, or marshy grounds, in quest of insects. The numbers of young frogs which suddenly make their appearance in the plains induced Rondeletius, and many other naturalists, to imagine that they were generated in the clouds, and showered down upon the earth. But if, like Mr. Derham, they had examined the situation of the place with regard to stagnating waters, and attended to the nature and transformation of the animals, they would soon have discovered the real cause of the phenomenon.

Of all migrating animals particular kinds of fishes make the longest journeys, and in the greatest numbers. The multiplication of the species, and the procuring of food, are the principal motives of their migration. The salmon, a fish which makes regular migrations, frequents the northern regions alone. It is unknown in the Mediterranean sea, and in all the rivers which fall into it. It is found in some of the rivers of France that empty themselves into the ocean. Salmon are taken in the rivers of Kamtschatka, and appear as far north as Greenland. They live both

in the ocean and in fresh waters. To deposit their spawn they quit the sea in the month of September, and ascend the rivers. So strong is the instinct of migrating, that they press up the rivers with amazing keenness, and scarcely any obstacle is sufficient to interrupt their progress. They spring, with great agility, over cataracts several feet in height. When they find a place which they think proper for depositing their eggs, the male and female unite their labours in forming a convenient receptacle for the spawn in the sand, which is generally about eighteen inches deep. In this hole the female deposits her eggs, and the male his milt, which they are said to cover carefully with their tails; for, after spawning, their tails are deprived of skin. The eggs, when not disturbed by violent floods, lie buried in the sand till the spring, and they are hatched about the end of March. The parents, however, after this important office has been performed, hasten back to the sea, in order to cleanse themselves, and to recover their strength. Toward the end of March, the young fry begin to appear, and they gradually increase in size till they acquire the length of four or five inches, and are then called smelts or smoults. About the beginning of May, all the considerable rivers of Scotland are full of salmon-fry; and, after this period, they migrate to the sea. About the middle of June, the earliest of the fry begin to appear again in the rivers. At that time they are from twelve to sixteen inches long, and gradually augment, both in number and size, till about the end of July or the beginning of August, when they weigh from six to nine pounds. This is a very rapid growth. But a gentleman of credit at Warrington informed Mr. Pennant of a growth still more rapid. A salmon, weighing seven pounds and three quarters, was taken on the seventh day of February. It was marked on the back, fin, and tail, with scissors, and then turned into the river.

It was retaken on the 17th day of the following month of March, and then it weighed seven pounds and a half. The season for fishing salmon in the Tweed begins on the 30th of November, and ends on old Michaelmas day. In that single river it is computed that no less than 208,000, at a medium, are annually caught, which, together with the products of many other rivers on both sides of Scotland, not only afford a wholesome and palatable food to the inhabitants, but also form a considerable article of commerce.

Herrings are likewise actuated by the migratory principle. They are chiefly confined to the northern and temperate regions of the globe. They frequent the highest latitudes, and are sometimes found on the northern coasts of France. They appear in shoals on the coast of America, as far south as Carolina. In Chesapeake bay there is an annual inundation of herrings; and they cover the shores in amazing numbers as to become offensive to the inhabitants. The great winter rendezvous of the herrings is within, or near, the arctic circle, where they remain several months, and acquire strength, after being weakened by the fatigues of spawning, and a long migration. In these seas, insect food is much more abundant than in warmer latitudes. They begin their migration southward in the spring, and appear off Shetland in April and May. These, however, are only the forerunners of the immense shoals which arrives in June. Their approach is recognised by particular signs, such as the appearance of certain fishes, the vast number of birds, as gannets and soland geese, which follow the shoal to prey upon the herrings. But, when the main body arrives, the breadth and depth are so great, as to change the appearance of the ocean itself. The shoal is generally divided into columns of five or six miles in length and three or four in breadth. Their progress

tion creates a kind of rippling or small undulations in the water. They sometimes sink and disappear for ten or fifteen minutes, and then rise again toward the surface. When the sun shines, a variety of splendid and beautiful colours are reflected from their bodies. In their progress southward, the first interruption they meet with is from the Shetland lands. Here the shoal divides into two branches. One branch skirts the eastern, and the other the western shores of Great Britain, and fill every bay and creek with their numbers. Those which proceed to the west from Shetland, after visiting the Hebrides, where the great fishery is carried on, move on till they are again interrupted by the north of Ireland, which obliges them to divide a second time. One division takes to the west, where they are scarcely received, being soon lost in the immensity of the Atlantic ocean. The other division goes into the Irish sea, and affords nourishment to many thousands of the human race. The chief object of herrings migrating southward is to deposit their spawn in warmer and more shallow seas than those of the frigid zone. This instinct seems not to be prompted by a scarcity of food; for, when they arrive upon our coasts, they are fat and in fine condition; but, when returning to the ocean, they are weak and emaciated. They continue in perfection from the middle of June to the beginning of winter, when they begin to deposit their spawn. The great stations of the herring fisheries are off the Shetland and the Western islands, and along the coast of Norfolk.

Beside salmons and herrings, there are many fishes which observe a regular migration, as mackerels, sprays, pilchards, &c. About the middle of July, the pilchards, which are a species of herrings, though smaller, appear in vast shoals off the coast of Cornwall. When winter approaches, like the herrings, they retire to the arctic seas. Though so nearly

allied to the herring; it is not incurious to remark, that the pilchards, in their migration for the purpose of spawning, choose a warmer latitude; for, off the coasts of Britain, the great shoals never appear further north than the county of Cornwall and the Scilly islands.

Of the land-crab there are several species: The migration of what is called the violet land-crab deserves some notice. It inhabits the warmer regions of Europe: but its particular residence is in the tropical climates of Africa and America. Land-crabs generally frequent the mountainous parts of the country, which are, of course, most remote from the sea. They inhabit the hollows of old trees, the clefts of rocks, and holes which they themselves dig in the earth. In April and May they leave the mountains, and march in millions to the sea-shore. At this period the whole ground is covered with them; and a man can hardly put down his foot without treading on them<sup>1</sup>. The object of their migration is to deposit their spawn on the sea-shore. In their progress toward the sea, like the northern rats, they move in a straight line. Even when a house intervenes, instead of deviating to the right or left, they attempt to scale the walls. But, when they meet with a river, they are obliged to wind along the course of the stream. In their migration from the mountains they observe the greatest regularity, and commonly divide into three bodies. The first consists of the strongest and boldest males, which, like pioneers, march forward to clear the way, and to face the greatest dangers. The females, which form the main body, descend from the mountains in regular columns, which are fifty paces broad, three miles long, and so close that they almost entirely cover the ground. Three or four days after-

<sup>1</sup> *Voyage aux Isles Francoises* par Labat, tom. ii, page 221.



ward, the rear guard follows, which consists of straggling undisciplined troops of males and females. They travel chiefly during the night; but, if it rain by day (for moisture facilitates their motion) they proceed in their slow uniform manner. When the sun shines, and the surface of the ground is dry, they make a universal halt till the evening, and then resume their march. When alarmed with danger, they run backward in disorder, and hold up their nippers in a threatening posture. They even seem to intimidate their enemies: for, when disturbed, they make a clattering noise with their nippers. But, though they endeavour to render themselves formidable to their enemies, they are cruel to each other. When an individual, by any accident, is so maimed that he cannot proceed, his companions immediately devour him, and then pursue their journey. After a fatiguing and tedious march, which sometimes continues three months before they reach the shore, they prepare themselves for depositing their spawn. The eggs still remain in the bodies of the animals, and are not excluded, as usual to this genus, under the tail. To facilitate the maturation and exclusion of the eggs, the land-crabs no sooner arrive on the shore, than they approach to the margin of the sea, and allow the waves to pass several times over their bodies. They immediately retire to the land; the eggs, in the mean time, come nearer to maturity, and the animals once more go to the water, deposit their eggs, and leave the event to Nature. The bunches of spawn are sometimes as large as a hen's egg; and it is not incurious to remark, that, at this very period, numbers of fishes of different kinds are anxiously waiting for this annual supply of food. Whether the painful migration of the land-crabs, or the wonderful instinct of the fishes which await their arrival, in order to devour their spawn, is the most astonishing fact, must be left to the consideration of

philosophers. The eggs which escape these voracious fishes are hatched under the sand. Soon after, millions of minute crabs are seen leaving the shore, and migrating slowly toward the mountains. Most of the old ones, however, remain in the flat parts of the country till they regain their strength. They dig holes in the earth, the mouths of which they cover with leaves and mud. Here they throw off their old shells, remain quite naked, and almost without motion for six days, when they become so fat that they are esteemed delicious food. When the new shell has hardened, the animals, by an instinctive impulse, march back to those mountains which they had formerly deserted. In Jamaica, where they are numerous, the land-crabs are regarded as great delicacies; and they are so abundant, that the slaves are often fed entirely upon them.

The migrating principle is not confined to men, quadrupeds, birds, and reptiles: it extends to many of the insect tribes. Numberless inhabitants of the air pass the first stages of their existence in the waters. There they remain for longer or shorter periods, according to the species. Previous to their transformation into chrysales, they quit the waters, and come upon dry ground, where they undergo their amazing change. Instead of active water-worms, they dig or find holes in the earth, where they are converted into chrysales, or seemingly inanimate beings, and, in a short time, mount into the air in the form of winged insects. Similar migrations are to be observed among land-insects. But migration is not confined to water-worms. Many species of caterpillars which feed upon the leaves of trees, shrubs, and other vegetables, when about to undergo their transformation, leave their former abodes, descend from the trees, and conceal themselves in the earth. The living of bees, when nu-

merous colonies remove in order to establish new settlements, is another instance of the migration of insects. Indeed, if we except bees, wasps, ants, and a few others, most insects, whether they inhabit the air, earth, or waters, are perfect wanderers, having no fixed place of residence. Some of them, as the spider tribes, build temporary apartments; but, when disturbed, they migrate to another commodious place, and erect new habitations.

From the facts which have been enumerated, it is apparent, that the principle of migration, or the desire of changing situations, is not confined to particular birds, but extends through almost the whole system of animation. Men, quadrupeds, birds, fishes, reptiles, insects, all afford striking examples of the migrating principle. From the same facts it is equally apparent, that the general motives for migrating are similar in every class of animals. Food, multiplication of species, and a comfortable temperature of air, are evidently the chief causes which induce animals to remove from one place to another, or what amounts to the same thing, from one climate to another. Partial emigrations, or emigrations to small distances, are prompted by the same instinctive motives which induce animals of a different structure to undertake long and fatiguing excursions. But, previous to actual migration, what are the peculiar feelings of different animals, and what should stimulate them to proceed uniformly in the direction that ultimately leads them to the situations most accommodated to their wants and their constitutions, are mysteries, with regard to which, like every other part of the economy of Nature, it is the duty of philosophers, instead of attempting to push their inquiries beyond the bounds of human ability, to observe a respectful silence.

No. LXVIII.

ON THE INSTINCT OF BRUTES.

Nor will it less delight th' attentive sage  
 T' observe that instinct, which unerring guides  
 The brutal race, which mimics reason's lore,  
 And oft transcends. SOMERVILLE.

This truth shines bright to human sense;  
 Each strong affection of th' unconscious brute;  
 Each bent, each passion of the smallest mite,  
 Is wisely given; harmonious they perform  
 The work of perfect reason. DYER.

THE Divine Wisdom and Goodness may be still further demonstrated, not merely from the senses of animals in general, of which I have recently treated, but in the provision which he has made for the brute creation in particular, by that wonderful faculty which we call instinct; and which I would define to be a natural disposition or sagacity with which animals are endued, and by virtue of which they are enabled to provide for themselves, to know what is good for them, and are determined to propagate and preserve their species.

Many of the ancient philosophers ascribed to brutes an understanding, differing only in degree from that of man, and attributed their inferiority to the want of proper and sufficient bodily organs. This system has been very strenuously supported by M. Helvetius, in his treatise *De l'Esprit*. Among the moderns, the learned Dr. Cudworth endeavoured to explain the instinct of animals, by means of a certain *plastic* nature. Des Cartes thought that all the actions of brute animals might be explained by the simple laws of mechanism. He considered them as

machines totally devoid of life and sentiment, but so curiously constructed by the Creator, that the mere impressions of light, sound, and other external agents, on their organs, produced a series of motions on them, and caused them to execute those various operations, which had before been ascribed to a certain principle of life and spontaneity. But the actions and manners of animals, which are totally incompatible with the mere principles and laws of mechanism, evince the absurdity of this opinion. The celebrated Buffon, however, adopts it in part; but he allows them life, and the faculty of distinguishing between pleasure and pain, together with a strong inclination to the former, and aversion from the latter. By these inclinations and aversions, he undertakes to account for all, even the most striking operations of animals; affirming that, in consequence of impressions made on the brain, by means of the sensitive organs, and by the reaction of the brain and nerves on the muscles, these machines acquire a motion conformable to the nature of the animal, and of the impressions of the different objects which act upon their organs, and excite desire or aversion.

The *pre-established harmony* of Leibnitz has also been applied to explain the actions of brute animals. Others have considered their actions as produced by the constant and immediate influence of the Divine Energy, directing all their inclinations and motions: such appears to have been the opinion of Mr. Addison<sup>1</sup>. The Abbé de Condillac, in his Essay on the

<sup>1</sup> There is not, in my opinion, any thing more mysterious in nature than this instinct in animals, which thus rises above reason, and falls infinitely short of it. It cannot be accounted for by any properties in matter, and, at the same time, it works after so odd a manner, that we cannot think it the faculty of an intellectual being. For my own part, I look upon it as upon the principle of gravitation in bodies, which is not to be explained by any known qualities inherent in the bodies themselves, nor from any laws of mechanism, but,



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Origin of Human Knowledge, and the  
 and the other have no sensation, get  
 by communication to animals, upon the  
 as objects of perception, as the senses  
 and the other animals, and the senses of all  
 on the assistance of reflection. The an-  
 o opinion of the subject have been  
 illustrated in M. Reimar's in his  
*Physique*, published in 1770. This in-  
 approach, and defining nature, is the  
 phenomena of the world, and the  
 inclination, accompanied with a power  
 to perform certain actions, divided in  
 three kinds. The first, which is called  
 instinct, belongs to the body, considers  
 organized substance, and are exercised  
 independently of the will of the animal.  
 those which produce the motion of the  
 lungs, the contraction and dilatation of  
 digestion, &c. This class of instincts is  
 in common both by men and brutes, a  
 measure, even by vegetables. The 2  
 comprehends those which in terms re-  
 instincts, which consist partly in the per-  
 ceive external objects by their present in  
 the senses, and partly by the faculty of  
 the ideas of these objects present to the  
 powers of imagination, or of memory, in  
 of the word. These are common to me-  
 animals, excepting that brutes possess the  
 imagination only in common with us, a  
 of memory, in the strict and proper s  
 word. Indeed, M. Reimar endeavours  
 that the knowledge of brutes does not n

according to the best notions of the greatest ph  
 an immediate impression from the First Mover, a  
 energy acting in the creatures.'

in degree from that of man, but that it is of a kind entirely different from it; and that they are incapable both of memory and reasoning: the faculty of imagination serving to give them a confused idea of events that are past, by the view or other impressions of objects that are present. The third and principal class of instincts is that which comprehends all those which he calls *spontaneous*. This species of instinct is not attended with any power of reflection, determining the animal to decide freely between two different modes of action present to his imagination; nor is it merely corporeal or mechanical. It is put into action by the natural and primitive principle of self-love, implanted in all animated beings; or by a love of pleasure and aversion from pain, producing a voluntary inclination to perform certain actions which tend to their wellbeing and preservation. To the performance of these actions they are particularly prompted by their present sensations, by imagination supplying the place of memory, and by other causes. The wonderful effects produced by these instinctive appetites, are further to be attributed to the exquisite mechanism in their bodily conformation, particularly in the structure of their various organs with which they execute their operations, and to the superior perfection and acuteness of their external senses, by which they are quickly and distinctly informed of those qualities of objects which most materially concern them. In order to account for the more curious and surprising operations of brute animals, M. Reinar adds two other principles; namely, first, an internal distinct perception of the precise power and proper use of their various bodily organs, together with an innate knowledge of the qualities of those objects around them in which they are interested; and, secondly, certain innate and determinate powers and inclinations, impressed by the Author of Nature, *a priori*, on the

soul itself; by which they are arbitrarily, and without their own knowledge or consciousness, directed and irresistibly impelled to the performance of those various operations, which they execute with such unremitting industry and art.

I have succinctly stated these different opinions concerning the instinct of brutes, without pretending to determine which is right. There will ever be phenomena in nature, on which we may reason, but on which we cannot decide. The instinct of brutes seems to have been originally implanted in them by the Great Creator, to compensate, as it were, for not granting them the nobler faculty of reason. These instincts are diversified in a thousand ways, and appropriated to their respective wants. Animals have instincts for motion; instincts to provide for their subsistence, to discern, to find, to seize, and to prepare it; instincts to construct their nests and other habitations; instincts for the propagation of their species, for self-defence, and every other requisite occasion. In a word, it seems unquestionable that instinct in brutes bears some analogy, however inferior it be, to reason in mankind.

Whether with reason, or with instinct blest,  
Know, all enjoy that power which suits them best:  
To bliss alike by that direction tend,  
And find the means proportioned to their end.  
Say, when full instinct is th' unerring guide,  
What pope or council can they need beside?  
Reason, however able, cool at best,  
Cares not for service, or but serves when prest;  
Stays till we call, and then not often near;  
But honest instinct is a volunteer,  
Sure never to o'ershoot, but just to hit,  
While still too wide or short is human wit;  
Sure by quick nature happiness to gain,  
Which heavier reason labours at in vain.  
This too serves always, reason never long:  
One must go right, the other may go wrong.  
See then the acting and comparing powers  
One in their nature, which are two in ours!

And reason raise o'er instinct as you can,  
In this 'tis God directs, in that 'tis man.

Who taught the nations of the field and wood  
To shun their poison and to choose their food?  
Prescient, the tides and tempests to withstand,  
Build on the wave, or arch beneath the sand?  
Who made the spider parallels design,  
Sure as *De Moivre*, without rule or line?  
Who bid the stork, *Columbus*-like, explore  
Heavens not his own, and worlds unknown before;  
Who calls the council, states the certain day,  
Who forms the phalanx, and who points the way?

POPE.

From the various instances of the force of instinct in the brute creation, I shall select a few only, which cannot but excite the admiration of the rational observer. This wonderful instinct, whatever it be, directs every different kind of bird to observe a particular plan in the structure of its nest, and directs all the same species to work after the same model. This, certainly, cannot be imitation; for though you watch a crow under a hen, and never let it see any of the works of its own kind, the nest it makes shall be the same, to the laying of a stick, with all the other nests of the same species. It cannot be reason; for were animals endued with it to as great a degree as man, their buildings would be as different as ours, according to the different conveniences that they would propose to themselves, and the opportunities they would have of improving by the example of others.

The force of this instinct is greater or less, in proportion as the particular object of it renders it requisite; for instance, in the propagation and rearing of the species. With what caution does the hen provide herself a nest in places unfrequented, and free from noise and disturbance! When she has laid her eggs in such a manner that she can cover them, what care does she take in turning them frequently, that all parts may partake of the vital warmth!

When she leaves them, to provide for her necessary sustenance, how punctually does she return before they have time to cool, and become incapable of producing an animal! In the summer, you see her giving herself greater liberty, and quitting her care for above two hours together; but in winter, when the rigour of the season would chill the principles of life, and destroy the young ones, she grows more assiduous in her attendance, and stays away but half the time. When the birth approaches, with how much nicety and attention does she help the chick to break its prison! Not to take notice of her covering it from the injuries of the weather, providing it proper nourishment, and teaching it to help itself; nor to mention her forsaking the nest, if, after the usual time of reckoning, the young one does not make its appearance. A chemical operation could not be followed with greater art or diligence than is seen in the hatching of a chick; although there are many other birds that show far greater sagacity in all the forementioned particulars.

But, at the same time, the hen, which has all this seeming ingenuity (which, indeed, is absolutely necessary for the propagation of the species) considered in other respects, is without the least glimmering of thought or common sense. She mistakes a piece of chalk for an egg, and sits on it in the same manner; she is insensible of any increase or diminution in the number of those she lays: she does not distinguish between her own, and those of another species; and when the birth appears of ever so different a bird, will cherish it for her own. In all these circumstances, which do not carry an immediate regard to the subsistence of herself or her species, she is a very idiot. In other birds too, the object of this instinct appears to be merely the preservation of their species: for, notwithstanding the natural love of brutes is much more violent and intense than in rational



creatures, Providence has taken care that it shall be no longer troublesome to the parent than it is useful to the young; for as soon as the wants of the latter cease, the mother withdraws her fondness, and leaves them to provide for themselves: and what is a very remarkable circumstance in this part of instinct, we find that the love of the parent may be lengthened out beyond its usual time, if the preservation of the species require it; as we may see in birds that drive away their young as soon as ever they are able to get their livelihood, but continue to feed them, if they are tied to the nest, confined in a cage, or by any other means appear not in a condition to supply their own necessities.

In the choice of their food, both with respect to what is salutary, and even what is medicinal, sheep are particularly sagacious:

Driv'n oft from nature's path by artful man,  
Who blindly turns aside with haughty hand,  
Whom sacred instinct would securely lead.  
By their All-perfect Master inly taught,  
They best their food and physic can discern;  
For He, Supreme Existence, ever near,  
Informs them. O'er the vivid green observe  
With what a regular consent they crop,  
At every fourth collection to the mouth,  
Unsavoury crow-flower; whether to awake  
Languor of appetite with lively change,  
Or timely to repel approaching ills,  
Hard to determine.

DYER.

Somerville, in the second book of his poem, the Chase, gives a fine description of the instinctive stratagems, which the roebuck and the hare employ to escape from their pursuers.

And others are wonderfully provident in laying up stores against a time of scarcity; as the bee, whose history would alone fill a volume.

But an enumeration of all the powerful operations of instinct in the various kinds of animals would

carry me too far. Let it suffice, then, to observe here, that man, with all the pride of reason, may have been indebted for some of the most useful arts to their ingenious labours; as I have noticed in a former paper<sup>1</sup>.

The many wonderful circumstances observable in the instinct of brutes, have given rise to this saying of a modern philosopher, *Deus est anima brutorum*, God is the soul of brutes; an idea similar, but in a bolder form of words, to that already quoted from Mr. Addison. But many think it unphilosophical to attribute that to the *immediate* agency of the Deity, which is the result of laws, which he *originally* established; for he has been pleased to govern the material universe by the intervention of a variety of second causes; all, indeed, under the constant guidance of his overruling providence, and all ultimately leading to the contemplation and adoration of Him, the Great First Cause and Mover of all.

I shall conclude this paper with an excellent argument for a future state, which Dr. Young has deduced from the consideration of the imperfection of reason in man, and the perfection of instinct in brutes.

Reason progressive, instinct is complete;  
 Swift instinct leaps; slow reason feebly climbs;  
 Brutes soon their zenith reach; their little all  
 Flows in at once; in ages they no more  
 Could know, or do, or covet, or enjoy.  
 Were man to live coëval with the sun,  
 The patriarch pupil would be learning still;  
 Yet, dying, leave his lesson half unlearn't.  
 And why?  
 His *immortality* alone can tell.

<sup>1</sup> No. LXIII, On the Principles of Association.

## No. LXIX.

THE FORCE OF INSTINCT EXEMPLIFIED  
IN THE NATURAL HISTORY OF THE  
BEAVER.

Were they as vain as gaudy-minded man,  
As flatulent with fumes of self-applause,  
Their arts too animals might boast.

YOUNG.

IN my preceding paper I intimated, that the bee, a particular, would furnish a copious subject, illustrative of the wonderful force of instinct. But as the curious operations of these industrious insects are within the reach of actual inspection, I shall be content, at present, to have recourse to the natural history of the beaver; a creature, whose sagacity is so astonishing, that we may well apply to it what the poet says of the elephant:

How instinct varies in the grov'ling swine,  
Compared, half-reasoning elephant, with thine!  
'Twixt that, and reason, what a nice barrier!  
For ever separate, yet for ever near!

POPE.

Of all animals that live in society, none, indeed, approach nearer to human understanding than the beavers. We are struck with astonishment at the sight of their work; and, on reading their history, are apt to imagine it to be that of a species of men. We are at a loss to determine which is most wonderful in their labours; whether the grandeur and solidity of the undertaking, or the exquisite art, fine views, and general design, so excellently displayed throughout every part of their execution. A society of beavers seems to be an academy of engineers,

that proceed on rational plans, which they rectify or modify as they judge necessary; pursuing them with exactness and perseverance. They are all actuated by the same spirit, and unite their will and strength to promote one common end, which is invariably the general good of the society. In a word, we must be witnesses of their performances, before we can imagine them to be capable of them. The traveller that should inspect their habitations, without previous information, might think himself among a nation of savages.

The more remote from the tyranny of man, the greater seems to be the sagacity of animals. The beavers, in those distant solitudes where men have rarely passed, exert all the arts of architects and citizens. They build greater habitations than even the rational inhabitants of these countries can show, and obey a more regular discipline than ever man could boast. But as soon as man intrudes upon their society, their spirit of industry and wisdom ceases: they no longer exert their usual arts, but become patient and dull, as if to fit them for a state of servitude.

The American beaver was long unknown to our most curious and inquisitive naturalists, or, at least, the accounts we have had were so blended with falsehood and error, as to render them altogether of doubtful authority. The memoirs of the royal academy of sciences at Paris, and the researches, afterward, of the celebrated Buffon, have entirely dissipated every doubt.

The hair of this animal, which covers the whole body except the tail, is not alike throughout; for there are two sorts mixed together, which differ not only in length, but in colour and thickness. Part of it is about an inch and a half long, and as thick as the hair of a man's head, very shining, and of a brown colour, inclining somewhat to a tawny. It is

of a close substance, and so solid, that no cavity can be perceived by a microscope.—The shortest is about an inch long, and is in greater plenty than the former: it is likewise smaller and softer, insomuch that it feels almost like silk. This difference of the hair or fur is to be met with in several animals, but more particularly in the beaver, the otter, and the wild boar; which, perhaps, may be the more necessary for these creatures, because they delight in muddy places, and the longest hair may serve to keep the mud from penetrating to the skin.—The beavers vary in colour. They are sometimes found of a deep black, especially in the north; and, in the Leverian Museum, there was a specimen quite white. As they advance southward, the beauty of their fur decreases.—Among the Illinois they are tawny, and even of a straw colour.

The head, from the nose to the hind part, is five inches and a half long, and five inches broad from the prominence of the two cheek bones. The ears are like those of an otter, being round, and very short: they are covered with hair on the outside, but are almost naked within.—The common length of a beaver, from nose to tail, is about two feet four inches.

It is commonly said, that these animals delight in the gnawing of trees; and, in reality, their teeth seem to be very proper for that purpose, especially those below; but they are not sharp-pointed, to serve instead of a saw, as some have affirmed; or, at least, they are not in the American beaver; but they are proper to cut with, like those of squirrels, porcupines, and rats. The length of those below is above an inch; but the upper teeth are not quite so long; and they slip on the side of each other, because they are not directly opposite. They are half round on the outside, and of a bright red or orange



colour. They are about a quarter of an inch in breadth near the jaw; but are somewhat narrower at the extremity.—Beside the teeth, called the incisors, they have sixteen grinders, that is, eight on each side, four above and four below, and they are directly opposite to each other.

The structure of their feet is very extraordinary, and evinces evidently, that Nature designed these animals to live as well in the water as on the land: for, although they have four feet like terrestrial animals, yet those behind are as fit for swimming as walking, the five toes of which they consist being joined together like those of a goose, but their forefeet are like the hand of a man. They are covered with hair on the outside, and the nails are long and sharp.

These animals are found in great plenty, all round Hudson's Bay, and as low as Carolina and Louisiana. They are not known in East Florida, nor in South America. Mr. Pennant says, that the species commences in latitude 60, or about the River of Seals, in Hudson's Bay, and is lost in latitude 30, in Louisiana. From Hudson's Bay and Canada, he traces them westward to 120 degrees of longitude, as far as the tract west of Lac Rouge, or the Red Lake. He thinks it probable, that they are continued to the western extremity of this great continent opposite to Asia; for the Russian adventurers got some of their skins on the isle of Radjak, which the natives must have had from America. However, they are certainly not found in the islands of the New Archipelago; nor yet in Kamtschatka, on account of the interruption of woods beyond the river Konyma. From this place, he doubts whether they are to be met with *associated*, or in a *civilized* state, nearer ~~than~~ the banks of the river Jenesei, or the Konda, ~~and other~~ rivers which run into the Oby. But, in

their *unsociable* state, they are found in the woody parts of independant Tartary, in Russia, Lapland, Norway, and Sweden.

The American, or, as we call them, the *associated* and *civilized* beavers, are the most sagacious and industrious of animals; and, as observed before, they erect edifices superior in contrivance to those of the savage human natives of their wilds. In order to form an habitation, they select a level piece of ground, with a small rivulet running through it. To effect their works, a community of two or three hundred assemble; and every individual of this community bears his share in the laborious preparations. Some fell trees of great size, by gnawing them asunder with their teeth, in order to form beams or piles; and they so contrive, that the tree constantly falls toward the water, that they may have the less way to carry it, when they have divided it into pieces. After they have done this, they each take a piece by itself, and roll it toward the water, where they intend to place it. The expedition with which they cut down these trees is amazing; for a number of them surround the body, and, in a few minutes, will gnaw through a tree two or three feet in circumference. Others are employed in rolling the pieces to the water; others dive, and scrape holes with their feet, in order to fix them; and another party exert their efforts to raise them in their proper places. A fifth party is busied in collecting twigs to wattle the piles; and a sixth is collecting earth, stones, and clay, which others carry on their broad tails to their proper places. These beat or temper the earth into mortar with their feet, or ram it between the piles, or plaster the inside of their houses.

These preparations are to form their dwellings within an artificial piece of water or pond, which they make by raising a dam across the level spot

on which they had pitched. This is done, first by driving into the ground stakes five or six feet long, placed in rows, and securing each row by wattling it with twigs, and filling the interstices with clay, rammed down close. The side next to the water is sloped; the other perpendicular. The bottom is from ten to twelve feet thick; the thickness gradually diminishing to the top, which is about two or three feet thick. The centre of the dam forms a segment of a circle, from which extends, on each side, a straight wing. In the centre of the dam, a gutter is usually left, for the waste water to discharge itself. These dams are often a hundred feet long, and neatly covered with turf.

The houses which these wise animals build are seated near the shore, in the water thus collected by means of the dam. They are erected upon piles, and are sometimes round, sometimes oval. The tops are vaulted, so that the inside resembles an oven, and the outside a dome. The walls are made of earth, stones, and sticks, and are usually two feet thick. They are commonly about eight feet high above the surface of the water, and are very neatly and closely plastered in the inside. The floor is a foot higher than the water. The house, sometimes, has only one floor, which is strewed with leaves or moss, on which each beaver lies in its proper place. At other times, there are three apartments; one to lodge, a second to eat in, and a third to dung in, for they are very cleanly, and constantly cause the filth to be carried off by the inferior beavers.—M. du Pratz says, that the beavers in Louisiana form numbers of cells; and that each animal, or, more probably, each pair, possesses one. He says, that he has seen no less than fifteen of those cells surrounding the centre of one house. He also acquaints us, that the beavers of Louisiana are a third less than

the brown sort, and that they are covered with a cinereous down, over which are long silvery hairs.

In each house are two openings; one is toward the land; the other is within, and communicates with the water, for the conveniency of getting to their magazine of provisions in frosty weather. This orifice is formed so as to be below the thickness of the ice; for they lodge their provisions under the water, and dive, and bring it into the house, as they want it. They begin to build these houses when they form a new settlement in the summer, and it costs them a whole season to finish their work, and to lay in their provisions.

These beavers seem to be among quadrupeds what bees are among insects. They have a chief, or superintendant, in their works, who directs the whole; and the utmost attention is paid to him by the whole community. Each individual has a task allotted, which he undertakes with the utmost alacrity. The overseer gives a signal, by a certain number of slaps with his tail, expressive of his orders. The moment the artificers hear it, they hasten to the place thus pointed out, and perform the allotted labour; whether to draw the wood, to carry the clay, or repair any accidental breach.— They have also their centinels among them, who, by the same kind of signal, give notice of any apprehended danger. They have, moreover, says Mr. Graham, a sort of slavish beaver among them (analogous to the drone) which they employ in servile works, and the domestic drudgery.

The number of houses in each pond is from ten to twenty-five; the number of animals in each from two to thirty. They are supposed to associate in pairs. They are, therefore, monogamous, which is another proof of their approach to civilization.

Their food, which is laid in before winter, by the tenants of each house, consists of the bark and boughs of trees. Mr. Lawson says, that they are fondest of the sassafras, ash, and sweet gum. In summer, they live on leaves, fruit, and sometimes crabs and crawfish: but they are not fond of fish.

Their sagacity in laying in their winter provision is wonderful. They cut the wood they prefer into certain lengths; these they pile in heaps beneath the water, to keep them moist; and when they want food, they bite the wood into small pieces, and bring it into their houses. Father Charlevoix says, that the Indians observe the quantity which the beavers lay in at the approach of winter; and that it is the almanack of the savages, who judge, from the greater or less stock, of the severity or mildness of the approaching season.

The beavers of America have a variety of lakes and waters, in which they might fix their seats; but their sagacity informs them of the precarious tenure of such dwellings, which are liable to be overthrown by every flood. This is their inducement for undertaking their vast and wonderful labours, in places where no such inconvenience can be felt. Having, therefore, formed a dam, as before observed, to support a reservoir, fed only by a rivulet, they have nothing to fear but from land floods, or the sudden melting of the snows. These, sometimes, make breaches, or damage their houses; but the defects are instantly repaired.

In a word, so wonderful are the sagacity, the skill, and the labours of beavers, that, as M. Bonnet observes, they will ever remain an impenetrable enigma to philosophers. They are endued, he thinks, with a kind of understanding, which seems to place them between man and other animals. Their works, indeed, bear the greatest resemblance



those of man; and were we to judge of them in their first impression upon us, we should be to conclude that these animals were actually endued with understanding and reflection. But, from closer inspection, it will appear, that in all their architecture, they are not actuated by reflection, but that instinct which is innate in them. Were they capable of reflection, they might build very differently now from what they did formerly; and should perceive, in their habitations, the traces of greater perfection, and continual improvement. But we may perceive, that they adhere invariably to their ancient methods; and that they never depart from the circle which nature has prescribed to them. The beavers, therefore, build no otherwise now, than they did before the deluge.—This, however, does not diminish our admiration of them; for of all animals that live in society, these, certainly, approach the nearest to human reason; and they leave us in astonishment, to exclaim with the poet of the *Sons*,

What is this Mighty Breath, ye sages, say,  
That in a powerful language, felt, not heard,  
Instructs them?

## No. LXX.

ON THE HABITATIONS OF ANIMALS IN  
GENERAL.

Behold the acing and comparing powers  
 One in their nature, which are two in ours !  
 And reason raise o'er instinct as you can,  
 In this 'tis God directs, in that 'tis man. POPE.

INSTINCTIVE ingenuity, in the construction of their habitations, is not confined to insects: it is visible, for the same common ends, in the admirable contrivances of quadrupeds and birds. In some former papers, I entered into a discussion of instinct in general<sup>1</sup>, exemplified by the natural history of the beaver<sup>2</sup>, and by some observations on the nidification of birds<sup>3</sup>; and I shall devote my present essay to some considerations on the habitations of animals in general.

With regard to quadrupeds, many of them employ no kind of architecture, but live constantly in the open air. When not under the immediate protection of man, they shelter themselves in rough, or stormy weather, among trees or bushes, or retire under the coverture of projecting rocks, or the sides of hills opposite to those from which the wind proceeds. Beside these arts of defence, to which they are prompted by instinct and experience, Nature furnishes them, during the winter months, with a double portion of long hair, which protects them from cold, and other assaults of the weather.

Of the quadrupeds that make or choose habitations for themselves, some dig holes in the earth,

<sup>1</sup> No. LXVIII.<sup>2</sup> No. LXIX.<sup>3</sup> No. LXIV.

some take refuge in the cavities of decayed trees, and in the clefts of rocks, and some actually construct cabins or houses. But the artifices they employ, the materials they use, and the situations they select, are so various, and so numerous, that I am necessarily confined to a few of the more curious examples.

Of the operations and architecture of the beaver, I have already, as observed above, given a very ample account. The Alpine marmot is a quadruped about sixteen inches in length, and has a short tail. In figure, the marmots have some resemblance both to the rat and to the bear. When tamed, they eat every thing presented to them; as flesh, bread, fruit, roots, herbs, insects, &c. They delight in the regions of frost and snow, and are only to be found on the tops of the highest mountains. They remain in a torpid state during winter. About the end of September or beginning of October, they retire into their holes, and never come abroad again till the beginning of April. Their retreats are formed with much art and precaution. With their feet and claws, which are admirably adapted to the purpose, they dig the earth with amazing quickness, and throw it behind them. They do not make a simple hole, or a straight or winding tube, but a kind of gallery in the form of a Y, each branch of which has an aperture, and both terminate in a capacious apartment, where several of the animals lodge together. As the whole operation is performed on the declivity of a mountain, this innermost apartment is alone horizontal. Both branches of the Y are inclined. One of the branches descends under the apartment, and follows the declivity of the mountain. This branch is a kind of aqueduct, and receives and carries off the excrements of the animals; and the other, which rises above the principal apartment, is used for coming in and going out. The place of their

abode is well lined with moss and hay, of which they lay up great store during the summer. They are social animals. Several of them live together, and work in common when forming their habitations. Thither they retire during rain, or upon the approach of danger. One of them stands centinel upon a rock, while the others gambol upon the grass, or are employed in cutting it, in order to make hay. If the centinel perceives a man, an eagle, a dog, or other dangerous animal, he alarms his companions by a loud whistle, and is himself the last that enters the hole. As they continue torpid during winter, and, as if they foresaw that they would then have no occasion for victuals, they lay up no provisions in their apartments. But, when they feel the first approaches of the sleeping season, they shut up both passages to their habitation; and this operation they perform with such labour and solidity, that it is more easy to dig the earth any where else than in such parts as they have thus fortified. At this time they are very fat, weighing sometimes twenty pounds. They continue to be plump for three months; but afterward they gradually decline, and, at the end of winter, are extremely emaciated. When seized in their retreats, they appear rolled up in the form of a ball, and covered with hay. In this state, they are so torpid that they may be killed without seeming to feel pain. The hunters select the fattest for eating, and keep the young ones for taming. Like the dormice, and all the other animals which sleep during winter, the marmots are revived by a gradual and gentle heat: and it is remarkable, that those which are fed in houses, and kept warm, never become torpid, but are equally active and lively during the whole year.

The habitation where moles deposit their young merits a particular description; because it is constructed with peculiar intelligence, and because the



mole is an animal with which we are well acquainted. They begin by raising the earth, and forming a pretty high arch. They have partitions, or a kind of pillars, at certain distances, beat and press the earth, interweave it with the roots of plants, and render it so hard and solid, that the water cannot penetrate the vault, on account of its convexity and firmness. They then elevate a little hillock under the principal arch; upon the latter they lay herbs and leaves for a bed to their young. In this situation they are above the level of the ground, and, of course, beyond the reach of ordinary inundations. They are, at the same time, defended from the rains by the large vault that covers the internal one, upon the convexity of which last they rest along with their young. This internal hillock is pierced on all sides with sloping holes, which descend still lower, and serve as subterraneous passages for the mother to go in quest of food for herself and her offspring. These by-paths are beaten and firm, extend about twelve or fifteen paces, and issue from the principal mansion like rays from a centre. Under the superior vault we likewise find remains of the roots of the meadow saffron, which seem to be the first food given to the young. From this description it appears, that the mole never comes abroad but at considerable distances from her habitation. Moles, like the beavers, pair; and so lively and reciprocal an attachment subsists between them, that they seem to disrelish all other society. In their dark abodes they enjoy the placid habits of repose and solitude, the art of securing themselves from injury, of almost instantaneously making an asylum or habitation, and of procuring a plentiful subsistence without the necessity of going abroad. They shut up the entrance of their retreats, and seldom leave them, unless compelled by the admission of water, or when their mansions are demolished by art.



The nidification of birds has at all times deservedly called forth the admiration of mankind. Their nests, in general, are built with such exquisite art, that an exact imitation of them exceeds all the powers of human skill. Their style of architecture, the materials they employ, and the situations they select, are as various as the different species. Individuals of the same species, whatever region of the globe they inhabit, collect the same materials, arrange and construct them in the same form, and make choice of similar situations for erecting their temporary habitations; for the nests of birds, those of the eagle-kind excepted, after the young have come to maturity, are for ever abandoned by the parents.

To describe minutely the nests of birds would be a vain attempt. Such descriptions could not convey an adequate idea of their architecture to a person who had never seen one of those beautiful and commodious habitations, which even astonish and excite the amazement of children.

The different orders of birds exhibit great variety in the materials and structure of their nests. Those of the rapacious tribes are in general rude, and composed of coarse materials, as dried twigs, bents, &c. But they are often lined with soft substances. They build in elevated rocks, ruinous and sequestered castles and towers, and in other solitary retirements. The aërie or nest of the eagle is quite flat, and not hollow, like those of other birds. The male and female commonly place their nest between two rocks, in a dry and inaccessible situation. The same nest, it is said, serves the eagle during life. The structure is so considerable, and composed of such solid materials, that it may last many years. Its form resembles that of a floor. Its basis consists of sticks about five or six feet in length, which are supported at each end, and these are covered with several

layers of rushes and heath. An eagle's nest was found in the Peak of Derbyshire, which Willoughby describes in the following manner: 'It was made of great sticks, resting one end on the edge of a rock, the other on a birch tree. Upon these was a layer of rushes, and over them a layer of heath, and on the heath rushes again; upon which lay one young, and an addle egg; and by them a lamb, a hare, and three heath pouts. The nest was about two yards square, and had no hollow in it.' But the butcher-birds, or shrikes, which are less rapacious than eagles and hawks, build their habitations in shrubs and bushes, and employ moss, wool, and other soft materials.

The birds belonging to the order of Pies in Mr. Pennant's *Genera of Birds*, are extremely irregular in constructing their nests. The common magpies build their nests in trees, and their structure is admirably contrived for affording warmth and protection to their young. The nest is not open at top: it is covered, in the most dexterous manner, with an arch or dome, and a small opening in the side of it is left, to give the parents an opportunity of passing in and out at their pleasure. To protect their eggs and young from the attacks of other animals, the magpies place, all round the external surface of their nest, sharp briars and thorns. The long-tailed titmouse, or oxeye, builds nearly like the wren, but with still greater art. With the same materials as the rest of the structure, the titmouse builds an arch over the top of the nest, which resembles an egg erected upon one end, and leaves a small hole in the side for a passage. Both eggs and young, by this contrivance, are defended from the injuries of the air, rain, cold, &c. That the young may have a soft and warm bed, she lines the inside of the nest with feathers, down, and cobwebs. The sides and

roof are composed of moss and wool interwoven in the most curious and artificial manner.

I have before mentioned<sup>1</sup>, that, in warm climates, many small birds suspended their nests on tender twigs of trees, to prevent their being destroyed by monkeys. In Europe, there are only three birds which build pensile nests, namely, the common oriola, the *parus pendulinus*, or hang-nest titmouse; and another pensile nest, belonging to some unknown bird, was lately discovered by Mr. Pennant, near the house of Blair in Athole, in the north of Scotland. In a spruce fir-tree, Mr. Pennant remarks<sup>2</sup>, was a hang-nest of some unknown bird, suspended at the four corners to the boughs. It was open at top, an inch and a half diameter, and two inches deep: the sides and bottom thick; the materials moss, worsted, and birch bark, lined with feathers.

It is a singular, though a well attested fact, that the cuckoo makes no nest, and neither hatches nor feeds her own young. ‘The hedge-sparrow (says Mr. Willoughby) is the cuckoo’s nurse, but not the hedge-sparrow only, but also ringdoves, larks, finches. I myself, with many others, have seen a wagtail feeding a young cuckoo. The cuckoo herself builds no nest; but having found the nest of some little bird, she either devours or destroys the eggs she there finds, and, in the room thereof, lays one of her own, and so forsakes it. The silly bird returning, sits on this egg, hatches it, and, with a great deal of care and toil, broods, feeds, and cherishes the young cuckoo for her own, until it be grown up and able to fly and shift for itself. Which thing seems so strange, monstrous, and absurd, that for my part I cannot sufficiently wonder there should

<sup>1</sup> See No. LXIV.      <sup>2</sup> Tour in Scotland, vol. i. page 104.



be such an example in Nature ; nor could I ever have been induced to believe that such a thing had been done by Nature's instinct, had I not with mine own eyes seen it. For Nature, in other things, is wont constantly to observe one and the same law and order, agreeably to the highest reason and prudence ; which in this case is, that the dams make nests for themselves, if need be, sit upon their own eggs, and bring up their own young after they are hatched<sup>1</sup>. This economy, in the history of the cuckoo, is not only singular, but seems to contradict one of the most universal laws established among animated beings, and particularly among the feathered tribes, namely, the hatching and rearing of their offspring. Still, however, like the ostrich in very warm climates, though the cuckoo neither hatches nor feeds her young, she places her eggs in situations where they are both hatched and her offspring brought to maturity. Here the stupidity of the one animal makes it a dupe to the rapine and chicane of the other ; for the cuckoo always destroys the eggs of the small bird before she deposits her own.

Most of the passerine or small tribes build their nests in hedges, shrubs, or bushes ; though some of them, as the lark and the goatsucker, build upon the ground. The nests of small birds are more delicate in their structure and contrivance than those of the larger kinds. As the size of their bodies, and likewise that of their eggs, are smaller, the materials of which their nests are composed are generally warmer. Small bodies retain heat a shorter time than those which are large. Hence the eggs of small birds require a more constant supply of heat than those of greater dimensions. Their nests, accordingly, are built proportionally warmer and deeper, and they are lined with softer substances. The larger birds,

<sup>1</sup> Willoughby's Ornithology, page 98.

of course, can leave their eggs for some time with impunity; but the smaller kinds sit most assiduously; for, when the female is obliged to go abroad in quest of food, the nest is always occupied by the male. When a nest is finished, nothing can exceed the dexterity of both male and female in concealing it from the observation of man, and of other destructive animals. If it is built in bushes, the pliant branches are disposed in such a manner as to hide it entirely from view. To conceal her retreat, the chaffinch covers the outside of her nest with moss, which is commonly of the same colour with the bark of the tree on which she builds. The common swallow builds its nest on the tops of chimneys; and the martin attaches hers to the corners of windows, or under the eaves of houses. Both employ the same materials. The nest is built with mud well tempered by the bill, and moistened with water to make it more firmly cohere; and the mud or clay is kept still firmer by a mixture of straw or grass. Within, it is neatly lined with feathers. Willoughby, on the authority of Bontius, informs us, ‘ That, on the seacoast of the kingdom of China, a sort of small party-coloured birds, of the shape of swallows, at a certain season of the year, namely, their breeding time, come out of the midland country to the rocks; and from the foam or froth of the sea water dashing and breaking against the bottom of the rocks, gather a certain clammy, glutinous matter, perchance the sperm of whales, or other fishes, of which they build their nests. These nests the Chinese pluck from the rocks, and bring them in great numbers into the East Indies to sell; which are esteemed by gluttons great delicacies, who, dissolving them in chicken or mutton broth, are very fond of them, preferring them far before oysters, mushrooms, or other dainty and lickerish morsels which most gratify the palate. — These nests are of a hemispherical figure, of the



bigness of a goose-egg, and of a substance resembling isinglass <sup>1</sup>.

Most of the cloven-footed waterfowls, or waders, lay their eggs upon the ground. But the spoonbill and the common heron build large nests in trees, and employ twigs and other coarse materials; and the storks build on churches, or on the tops of houses. Many also of the webfooted fowls lay their eggs on the ground, as the terns, and some of the gulls and mergansers. But ducks pull the down from their own breasts to afford a warmer and more comfortable bed for their young. The auks, the guillemots, and the puffins, lay their eggs on the naked shelves of high rocks. The penguins, for the same purpose, dig large and deep holes under ground.

It is not unworthy of remark, that birds uniformly proportion the dimensions of their nests to the number and size of the young to be produced. Every species lays nearly a determined number of eggs. But, if one be each day abstracted from the nest, the bird continues to lay daily more till her number is completed. Dr. Lister, by this practice, made a swallow lay no less than nineteen eggs.

Innumerable other particulars might be adduced of the force of instinct in the brute creation, with respect to their habitations. But sufficient have been enumerated, to evince how much the providential care of the Divine Being is extended over universal existence.—I shall conclude this paper with the observations of an ingenious writer<sup>2</sup>, on the beaver, in particular, which are well worthy the attention of the proud politicians of the human race, who are always warmly contending concerning the origin

<sup>1</sup> Willoughby's Ornithology, page 215.

<sup>2</sup> Smellie, in his Philosophy of Natural History.

and progress, the subversion and regeneration, or perhaps extinction of empires :

Next to the intelligence exhibited in human society, that of the beavers is the most conspicuous. Their operations in preparing, fashioning, and transporting the heavy materials for building their winter habitations, are truly astonishing ; and, when we read their history, we are apt to think that we are perusing the history of man in a period of society not inconsiderably advanced. It is only by the united strength, and co-operation of numbers, that the beavers could be enabled to produce such wonderful effects ; for, in a solitary state, as they at present appear in some northern parts of Europe, the beavers, like solitary savages, are timid and stupid animals. They neither associate, nor attempt to construct villages, but content themselves with digging holes in the earth. Like men under the oppression of despotic governments, the spirit of the European beavers is depressed, and their genius is extinguished by terror, and by a perpetual and necessary attention to individual safety. The northern parts of Europe are now so populous, and the animals there are so perpetually hunted for the sake of their furs, that they have no opportunity of associating ; of course, those wonderful marks of their sagacity, which they exhibit in the remote and uninhabited regions of North America, are no longer to be found. The society of beavers is a society of peace and affection. They never quarrel nor injure one another, but live together in different numbers, according to the dimensions of particular cabins, in the most perfect harmony. The principle of their union is neither monarchical nor despotic. But the inhabitants of the different cabins, as well as those of the whole village, seem to acknowledge no chief or leader whatever. Their association pre-

sents to our observation a model of a pure and perfect republic, the only basis of which is mutual and unequivocal attachment. They have no law but the law of love and of parental affection. Humanity prompts us to wish that it were possible to establish republics of this kind among mankind. But the dispositions of men have little affinity to those of the beavers.'

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## No. LXXI.

### ON THE INSTINCT OF AFFECTION IN THE BRUTE CREATION.

'Tis love creates their melody, and all  
This waste of music is the voice of love;  
That even to birds, and beasts, the tender arts  
Of pleasing teaches. THOMSON.

Is it for thee the linnet pours his throat?  
Loves of his own and raptures swell the note. POPE.

THE great intention of Nature, in endowing almost every animal with a sexual attachment, is the multiplication and continuation of the respective species. But, with regard to man, and, in an inferior degree, to all pairing animals, love is the source of many other social and important advantages. Love, or a strong affection for a particular woman, is to young men, perhaps, one of the greatest incentives to virtue and propriety of conduct. This observation, however, I shall not pursue, as it is more

properly the subject of a moral essay. My present disquisition shall be confined to that instinct of Nature in the brute creation, taught by which, they form reciprocal attachments, and evince the most powerful and uncontrollable affection for their young.

The love of offspring, though not universal, is, perhaps, the strongest and most active principle in nature. It overcomes the sense of pain, and even the principle of self-preservation. Among many wonderful examples of this, may be mentioned that of a bitch, which, during the operation of dissection, licked her young, whose presence seemed to make her forget the most excruciating tortures; and, when they were removed, she uttered the most dolorous cries<sup>1</sup>.—Certain species of spiders inclose their eggs in a silken bag spun and wove by themselves. This bag they fix to their back, and carry it along with them wherever they go. They are extremely nimble in their motions. But, when the bag is forced from a spider of this kind, her natural agility forsakes her, and she falls into a languid state. When the bag is again presented to her, she instantly seizes it, and carries it off with rapidity. The young spiders no sooner escape from the eggs than they dexterously arrange themselves on the back of the mother, who continues, for some time, to carry them about with her, and to supply all their wants. Another species of spider attaches her bag of eggs to her belly. This spider is likewise very agile, and so ferocious and determined in the protection of her eggs, that she has been known to suffer death rather than relinquish them.—The hind spontaneously presents herself to be chased by the dogs, to prevent their attacking her fawn.—When the fox perceives that her young have been disturbed

<sup>1</sup> Smellie's *Philosophy of Natural History*.



in her absence, she carries them off, one after another, and conceals them in a new retreat.—Wasps feed their young, when in the worm or caterpillar state, in the same manner as pigeons and other birds that disgorge. The pigeon, after swallowing grain, retains it for some time in her stomach, till it is softened and macerated: she then disgorges, and throws it into the mouths of her young. ‘In the same manner (says Reaumur) I have observed a female wasp swallow a large portion of an insect: in a short time afterward, she traversed the different cells of her nest, disgorged the contents of her stomach, and distributed food in this half digested form to her young worms.’

All animals acquire a double portion of force and courage after they bring forth. A cow, at least in a domestic state, is a placid and phlegmatic animal: but, whenever she produces a calf, a wonderful change is exhibited: she instantly becomes vigilant, active, and even ferocious, in the defence of her young. A lioness deprived of her cubs presents the most dreadful picture of anxiety, rage, and rapacity. Descending lower in the scale of animation, the same change is to be remarked. A domestic hen is a timid, indocile, and obstinately stupid creature. Though chased, harassed, and even put in danger of her life, fifty times in a day, she never learns to avoid a garden, or any particular place which she is accustomed to frequent, or to which she is led by her appetite for food: but, the moment her chicken are hatched, instead of her usual timidity, she becomes as bold as a lion. When she thinks her young are in danger, she bristles up her feathers, assumes a fierceness in her eye, makes an alarming noise, and attacks, in the most furious manner, and without distinction, every animal that comes near her. By the suddenness of her onsets, she often alarms men,



and actually intimidates and beats off dogs, and other animals, that could devour her in an instant.

Though several of the insect tribes discover a strong attachment to their young, yet all those which undergo transformations, and do not form societies, must be completely ignorant of the existence of their progeny; because, in general, the parents die before the young are hatched. Nature, however, has endowed those species with an instinct which produces all the effects of parental affection: they uniformly deposit their eggs in substances which afford to the young, immediately after their escape from the egg, a nourishment adapted to their respective constitutions, and a comfortable and safe protection from injury. Thus, Nature, ever attentive to the continuation and happiness of her productions, however seemingly insignificant in the scale of being, often employs very different means to accomplish the same beneficent purposes.

Nature has unquestionably attached pleasure to all the necessary functions of animals. But this pleasure cannot be considered as the original cause of any particular action; for the experiment must be made before the animal can discover whether the result is to be agreeable or disagreeable. The truth is, that Nature has bestowed on the minds of all animated creatures a number of laws or instincts perfectly accommodated to the species, and which irresistibly compel them to perform certain actions. The effects of these laws we perceive: but the causes, or the modes by which they operate on animal minds, are inscrutable. We may and must admire, but we can never penetrate the mysteries of Nature.

Marriage, or pairing, though by no means a universal institution of Nature, is not unfrequently exhibited in the animal creation. In the feathered

race, for instance, the same impulse, or law of Nature, takes place among the partridge tribes, the swallows, the linnets, and, in general, all the small birds. The assiduity, attention, mutual affection, laborious vigilance, and stedfast fidelity of pairing animals, are truly admirable, and, to ingenious minds, afford the most exemplary admonitions to virtue and conjugal attachment. Indeed, in general, it is to be remarked, that all those species of animals, whose offspring require, for some time, the industry and support of both parents, are endowed with the instinct of selection, or of pairing. With regard to the feathered tribes, pairing is almost universal. A distinction, however, as to the duration and circumstances of their pairing, is to be observed. The young of all the small birds, as well as of most of the larger kinds, continue for some weeks in a weak and helpless condition. The mother is not, like quadrupeds, provided with organs fitted to secrete milk; of course, she is unable to nourish them out of her own body. She is therefore obliged to go abroad in quest of food for them. But the progeny are so numerous, that all her industry, if not assisted by the father, would be ineffectual for their support and protection. In all birds whose young are in this condition, the males and females not only pair, but each of them is endowed with the strongest parental affection. Both are equally anxious and industrious in procuring food for their mutual offspring. This parental care and attachment uniformly continue till the young are fledged, and have acquired sufficient strength to provide for themselves. Eagles, and some other birds of prey, continue faithfully in pairs for years, and perhaps during life. These facts afford a strong argument in favour of marriage among mankind. No animal remains so long in the infant and helpless state as the children of men; and no mother can, but with great diffi-

culty, procure nourishment for a numerous family. Here, as in the feathered tribes, the assistance of the father becomes indispensable. On this subject, a curious instinct merits attention. The male of most birds not only selects a female, but, with great assiduity, brings food to her when sitting on her eggs, and often relieves her by sitting on them himself.

I cannot forbear, in this place, to illustrate my subject, by some beautiful passages from Thomson, that accurate observer, and enthusiastic admirer, of rural nature:

The glossy kind  
Try every winning way inventive love  
Can dictate, and in courtship to their mates  
Pour forth their little souls.  
Connubial leagues agreed, to the deep woods  
They haste away, all as their fancy leads,  
Pleasure, or food, or secret safety prompts;  
That Nature's great command may be obeyed,  
Nor all the sweet sensations they perceive  
Indulged in vain.

The patient dam assiduous sits,  
Not to be tempted from her tender task,  
Or by sharp hunger, or by smooth delight,  
Though the whole loosened Spring around her blows.  
Her sympathizing lover takes his stand  
High on th' opponent bank, and ceaseless sings  
The tedious time away; or else supplies  
Her place a moment, while she sudden flits  
To pick the scanty meal. Th' appointed time  
With pious toil fulfilled, the callow young,  
Warmed and expanded into perfect life,  
Their brittle bondage break, and come to light,  
A helpless family, demanding food  
With constant clamour: O what passions then,  
What melting sentiments of kindly care,  
On the new parents seize! Away they fly  
Affectionate, and undesiring bear  
The most delicious morsel to their young;  
Which equally distributed, again  
The search begins.

Nor toil alone they scorn : exalting love,  
 By the great Father of the Spring inspired,  
 Gives instant courage to the *fearful* race,  
 And to the *simple* art. With stealthy wing,  
 Should some rude foot their woody haunts molest,  
 Amid a neighbouring bush they silent drop,  
 And whirring thence, as if alarmed, deceive  
 Th' unfeeling schoolboy. Hence, around the head  
 Of wandering swain, the white-winged plover wheels  
 Her sounding flight, and then directly on  
 In long excursion skims the level lawn,  
 To tempt him from her nest. The wild-duck, hence,  
 O'er the rough moss, and o'er the trackless waste  
 The heath-hen flutters, pious fraud ! to lead  
 The hot pursuing spaniel far astray.

But now the feathered youth their former bounds,  
 Ardent, disdain ; and, weighing oft their wings,  
 Demand the free possession of the sky :  
 This one glad office more, and then dissolves  
 Parental love at once, now needless grown.  
 Unlavish Wisdom never works in vain.  
 'Tis on some evening, sunny, grateful, mild,  
 When nought but balm is breathing through the woods,  
 With yellow lustre bright, that the new tribes  
 Visit the spacious heavens, and look abroad  
 On nature's common, far as they can see,  
 Or wing, their range and pasture. O'er the boughs  
 Dancing about, still at the giddy verge  
 Their resolution fails ; their pinions still,  
 In loose libration stretched, to trust the void  
 Trembling refuse : till down before them fly  
 The parent-guides, and chide, exhort, command,  
 Or push them off. The surging air receives  
 Its plummy burden ; and their self-taught wings  
 Winnow the waving element. On ground  
 Alighted, bolder up again they lead,  
 Farther and farther on, the lengthening flight ;  
 Till, vanished every fear, and every power  
 Roused into life and action, light in air  
 Th' acquitted parents see their soaring race,  
 And once rejoicing never know them more.

The careful hen

Calls all her chirping family around,  
 Fed and defended by the fearless cock ;



Whose breast with ardour flames, as on he walks,  
 Graceful, and crows defiance. In the pond,  
 The finely chequered duck, before her train,  
 Rows garrulous. The stately-sailing swan  
 Gives out his snowy plumage to the gale;  
 And, arching proud his neck, with oary feet  
 Bears forward fierce, and guards his osier isle,  
 Protective of his young. The turkey nigh,  
 Loud-threatening reddens; while the peacock spreads  
 His ever-coloured glory to the sun,  
 And swims in radiant majesty along.  
 O'er the whole homely scene, the cooing dove  
 Flies thick in amorous chase, and wanton rolls  
 The glancing eye, and turns the changeful neck.

It would exceed the limits of this paper, if I were to extend my observations to quadrupeds, among whom pairing does not universally take place. There is one circumstance, however, which I cannot pass unnoticed, as it displays most conspicuously the over-ruling care of Providence; namely, that in the brute creation, with some few exceptions, the seasons of love are limited to particular times of the year. These seasons, though various, are admirably adapted to the nature and economy of the different species. They are so contrived, as well as the time of gestation, that the offspring, when brought forth, are amply supplied with the particular species of food upon which they principally live. To instance in the feathered race, the young of pairing birds are produced in the spring, when the weather begins to be comfortably warm, and their natural food abounds. In a word, the bringing forth, or hatching, of all animals, not excluding the insect tribes, uniformly takes place at those seasons of the year when the nature of the weather, and the food peculiar to the species, are best adapted to the constitution of their offspring. Caterpillars of every kind are never hatched till the various plants on which they feed, though they grow in different months, have put forth their leaves.



## No. LXXII.

ON THE ARTIFICES OF VARIOUS KINDS  
OF ANIMALS.

One portion of informing fire was given  
To brutes, th' inferior family of Heaven.

DRYDEN.

For He, Supreme Existence, ever near,  
Informs them.

DYER.

HAVING treated lately on the principle of association, and the instinct of affection, as they pervade the brute creation, I shall close my observations on animals in general, with some instances of the wonderful artifices which various kinds of them employ, either for self-preservation, or the protection of their young.

Many of these arts are purely instinctive, and others are acquired by experience and imitation. The love of life, the desire of multiplying and continuing the species, and that strong attachment which every animal has to its offspring, are the sources from which we must trace all the movements, dexterity, and sagacity of animals. The principle of self-preservation is strongly impressed upon the minds of all animated beings. It gives rise to innumerable arts of attack and defence, and not unfrequently to surprising exertions of sagacity and genius.

When cattle are attacked by a bear, or other rapacious animal, they instantly form a phalanx for mutual defence. In the same circumstances, horses rank up in lines, and beat off the enemy with their heels. Bishop Pontoppidon relates, that the small

Norwegian horses, when attacked by bears, instead of striking with their hind legs, rear, and, by quick and repeated strokes with their fore-feet, either kill the enemy, or oblige him to retire. This curious, and generally successful defence, is frequently performed in the woods, while a traveller is sitting on the horse's back. When the Norwegian horse, moreover, at such a juncture, has a mare or gelding with him, he generously puts them behind him, while he attacks the bear with his fore-legs; but if he should turn about to kick with his hind-legs, he is ruined, the bear, which has double his strength, instantly leaping, and fixing on his back, when the poor horse gallops on, till he drops down from the loss of blood<sup>1</sup>. It has often been remarked, that troops of wild horses, when sleeping, have always one of their number awake, who acts as a centinel, and gives notice of approaching danger.

The monkeys in Brazil, while they are sleeping on the trees, have uniformly a centinel to warn them of the approach of the tiger or other rapacious animals; and, if ever this centinel be found sleeping, his companions instantly tear him in pieces for his neglect of duty. For the same purpose, when a troop of monkeys are committing depredations on the fruits of a garden, a centinel is placed on an eminence, who, when any person appears, makes a chattering noise, when the rest immediately make their escape.

The deer-kind are remarkable for the arts they employ in order to deceive the dogs. With this view the stag often returns twice or thrice upon his former steps. He endeavours to raise hinds or younger stags to follow him, and to draw off the dogs from the immediate object of their pursuit. If he succeed in this attempt, he then flies off with

<sup>1</sup> Natural History of Norway, fol. 1755.

redoubled speed, or springs off at a side, and lies down on his belly to conceal himself. When in this situation, if by any means his foot be recovered by the dogs, they pursue him with more advantage, because he is now considerably fatigued. Their ardour increases in proportion to his feebleness; and the scent becomes stronger as he grows warm. From these circumstances the dogs augment their cries and their speed; and, though the stag employs more arts of escape than formerly, as his swiftness is diminished, his doublings and artifices become gradually less effectual. No other resource is now left him but to fly from the earth which he treads, and go into the waters, in order to cut off the scent from the dogs, when the huntsmen again endeavour to put them on the track of his foot. After taking to the water, the stag is so much exhausted, that he is incapable of running much farther, and is soon *at bay*, or, in other words, turns and defends himself against the hounds. In this situation he often wounds the dogs, and even the huntsmen, by blows with his horns, till one of them cuts his hams to make him fall, and then puts a period to his life.

The fallow-deer is more delicate, and approaches nearer to the domestic state than the stag. The males, during the rutting season, make a bellowing noise, but with a low and interrupted voice. They are not so furious as the stag. They never depart from their own country in quest of females; but they bravely fight for the possession of their mistresses. They associate in herds, which generally keep together. When great numbers are assembled in one park, they commonly form themselves into two distinct troops, which soon become hostile, because they are both ambitious of possessing the same part of the inclosure. Each of these troops has its own chief or leader, who always marches foremost, and he is uniformly the oldest and strongest of the

flock. The others follow him; and the whole draw up in order of battle, to force the other troop, who observe the same conduct, from the best pasture. The regularity with which these combats are conducted is singular. They make regular attacks, fight with courage, and never think themselves vanquished by one check; for the battle is daily renewed till the weaker are completely defeated, and obliged to remain in the worst pasture. They love elevated and hilly countries. When hunted, they run not straight out, like the stag, but double, and endeavour to conceal themselves from the dogs by various artifices, and by substituting other animals in their place. When fatigued and heated, however, they take the water, but never attempt to cross such large rivers as the stag. Thus, between the chase of the fallow-deer and of the stag, there is no material difference. Their sagacity and instincts, their shifts and doublings, are the same, only they are more frequently practised by the fallow-deer. As he runs not so far before the dogs, and is less enterprising, he has oftener occasion to change, to substitute another in his place, to double, and to return upon his former tracks, which renders the hunting of the fallow-deer more subject to inconveniencies than that of the stag.

The roebuck is inferior to the stag and fallow-deer both in strength and stature; but he is endowed with more gracefulness, courage, and vivacity. His eyes are more brilliant and animated. His limbs are more nimble; his movements are quicker, and he bounds with equal vigour and agility. He is likewise more crafty, conceals himself with greater address, and derives superior resources from his instincts. Though he leaves behind him a stronger scent than the stag, which increases the ardour of the dogs, he knows how to evade their pursuit, by

the rapidity with which he commences his flight, and by his numerous doublings.

Heaven-taught, the roebuck swift  
Loiters at ease before the driving pack,  
And mocks their vain pursuit: nor far he flies,  
But checks his ardour, till the steaming scent,  
That freshens on the blade, provokes their rage.  
Urged to their speed, his weak deluded soes,  
Soon flag fatigued; strained to excess each nerve,  
Each slackened sinew fails; they pant; they foam;  
Then o'er the lawn he bounds, o'er the high hills  
Stretches secure, and leaves the scattered crowd  
To puzzle in the distant vale below.      SOMERVILLE.

Hares possess not, like rabbits, the art of digging retreats in the earth. But they neither want instinct sufficient for their own preservation, nor sagacity to escape from their enemies.

'Tis instinct that directs the jealous hare  
To choose her soft abode. With steps reversed  
She forms the doubling maze; then, ere the morn  
Peeps through the clouds, leaps to her close recess.  
As wandering shepherds on the Arabian plains  
No settled residence observe, but shift  
Their moving camp; now, on some cooler hill  
With cedars crowned, court the refreshing breeze;  
And then, below, where trickling streams distil  
From some precarious source, their thirst allay,  
And feed their fainting flocks: So the wise hares  
Oft quit their seats, lest some more curious eye  
Should mark their haunts, and by dark treacherous wiles  
Plot their destruction; or perchance in hopes  
Of plentiful forage, near the ranker mead,  
Or matted blade, wary and close they sit.  
When spring shines forth, season of love and joy,  
In the moist marsh, 'mong beds of rushes hid,  
They cool their boiling blood. When summer suns  
Bake the cleft earth, to thick wide-waving fields  
Of corn full-grown, they lead their helpless young:  
But when autumnal torrents and fierce rains  
Deluge the vale, in the dry crumbling bank  
Their forms they delve, and cautiously avoid



The dripping covert. Yet when winter's cold  
 Their limbs benumbs, thither with speed returned  
 In the long grass they skulk, or shrinking creep,  
 Among the withered leaves, thus changing still,  
 As fancy prompts them, or as food invites.

SOMERVILLE.

The fox has, in all ages and nations, been celebrated for craftiness and address :

For all his father's wiles the fox retains. WEST.

Acute and circumspect, sagacious and prudent, he diversifies his conduct, and always reserves some art for unforeseen accidents. Though nimbler than the wolf, he trusts not entirely to the swiftness of his course. He knows how to insure safety, by providing himself with an asylum, to which he retires when danger appears. He is not a vagabond, but lives in a settled habitation and in a domestic state. The choice of situation, the art of making and rendering a house commodious, and of concealing the avenues which lead to it, imply a superior degree of sentiment and reflection. The fox possesses these qualities, and employs them with dexterity and advantage. He takes up his abode on the border of a wood, and in the neighbourhood of cottages. Here he listens to the crowing of the cocks and the noise of the poultry. He scents them at a distance. He chooses his time with great judgment and discretion. He conceals both his route and his design. He moves forward with caution, sometimes even trailing his body, and seldom makes a fruitless expedition. When he leaps the wall, or gets in underneath it, he ravages the court-yard, puts all the owls to death, and then retires quietly with one of them, which he either conceals under the herbage, or carries off to his kennel. In a short time he returns for another, which he carries off, and hides in the same manner, but in a different place. In this

anner he proceeds, till the light of the sun, or the movements perceived in the house, admonish him that it is time to retire to his den. He does much mischief to the bird-catchers. Early in the morning he visits their nets and their bird-lime, and tries off successively all the birds that happen to be entangled. The young hares he hunts in the fields, seizes old ones in their seats, digs out the rabbits in the warrens, finds out the nests of partridges, quails, &c. seizes the mother on the eggs, and destroys a prodigious number of game. When pursued, he runs to his hole; and it is not uncommon to send in terriers to detain him till the hunters move the earth above, and either kill or seize him there. The most certain method, however, of destroying a fox is to begin with shutting up his hole, station a man with a gun near the entrance, and then to search about with the dogs. When they fall with him, he immediately makes for his hole. If it, when he comes up to it, he is met with a discharge from the gun. If the shot misses him, he runs off with full speed, takes a wide circuit, and returns again to the hole, where he is fired upon a second time; but when he discovers that the entrance is shut, he darts away straight forward, with the intention of never revisiting his former habitation. He is next pursued by the hounds, whom he seldom fails to fatigue; because, with much cunning, he passes through the thickest part of the forest, or takes the most difficult access, where the dogs are hardly able to follow him; and, when he takes to the plains, he runs straight out, without either doubling or doubling. He is an exceedingly voracious animal. Beside all kinds of flesh and fishes, he devours eggs, cheese, fruits, and particularly apples. He is so extremely fond of honey, that he seeks the nests of wild bees. They at first put him to flight by numberless stings; but he retires

for the sole purpose of rolling himself on the ground, and of crushing the bees. He returns to the charge so often, that he obliges them to abandon the hive, which he soon uncovers, and devours both the honey and the wax. Some time before the female brings forth, she retires, and seldom leaves her hole, where she prepares a bed for her young. When she perceives that her retreat is discovered, and that her young have been disturbed, she carries them off, one by one, into a new habitation. The fox sleeps in a round form, like the dog; but, when he only reposes himself, he lies on his belly, with his hind-legs extended. It is in this situation that he eyes the birds on the hedges and trees. Birds have such an antipathy to him, that they no sooner perceive him than they send forth shrill cries to advertise their neighbours of the enemy's approach. The jays and blackbirds, in particular, follow the fox from tree to tree, sometimes two or three hundred paces, often repeating the watch-cries. Buffon kept two young foxes, which, when at liberty, attacked the poultry; but, after they were chained, they never attempted to touch a single fowl. A living hen was fixed near them for whole nights; and, though destitute of victuals for many hours, in spite of hunger and of opportunity, they never forgot that they were chained, and gave the hen no disturbance.

In Kamtschatka, the animals called *gluttons* employ a singular stratagem for killing the fallow-deer. They climb up a tree, and carry with them a quantity of that species of moss of which the deer are very fond. When a deer approaches near the tree, the glutton throws down the moss. If the deer stops to eat the moss, the glutton instantly darts down upon its back, and, after fixing himself firmly between the horns, tears out its eyes, which torments the animal to such a degree, that, whether to put an end to its

torments, or to get rid of its cruel enemy, it strikes its head against the trees till it falls down dead. The glutton divides the flesh of the deer into convenient portions, and conceals them in the earth to serve for future provisions. The gluttons on the river Lena kill horses in the same manner.

A species of rats in Kamtschatka make neat and spacious nests under ground. These are lined with turf, and divided into different apartments, in which the rats deposit stores of provisions for their support during the winter. It is worthy of remark, that the rats of this country never touch the provisions laid up for the winter, except when they cannot procure nourishment any where else. These rats, like the Tartars, change their habitations. Sometimes they totally abandon Kamtschatka for several years, and their retreat greatly alarms the inhabitants, which they consider as a presage of a rainy season, and of a bad year for hunting. The return of these animals is, of course, looked upon as a good omen. Whenever they appear, the happy news is soon spread over all parts of the country. They always take their departure in the spring, when they assemble in prodigious numbers, and traverse rivers, lakes, and even arms of the sea. After they have made a long voyage, they frequently lie motionless on the shore, as if they were dead. When they recover their strength they recommence their march. The inhabitants of Kamtschatka are very solicitous for the preservation of these animals. They never do the rats any injury, but give them every assistance when they lie weakened and extended on the ground. They generally return to Kamtschatka about the month of October; and they are sometimes met with in such prodigious numbers, that travellers are obliged to stop two hours till the whole troop passes. The track of ground they travel in a single summer is not less wonderful than the regularity they observe in

their march, and that instinctive impulse which enables them to foresee, with certainty, the changes of times and of seasons.

With regard to birds, their artifices are not less numerous nor less surprising than those of quadrupeds. The eagle and hawk kinds are remarkable for the sharpness of their sight and the arts they employ in catching their prey. Their movements are rapid or slow, according to their intentions, and the situation of the animals they wish to devour. Rapacious birds uniformly endeavour to rise higher in the air than their prey, that they may have an opportunity of darting forcibly down upon it with their pounces. To counteract these artifices, Nature has endowed the smaller and more innocent species of birds with many arts of defence. When a hawk appears, the small birds, if they find it convenient, conceal themselves in hedges or brushwood. When deprived of this opportunity, they often, in great numbers, seem to follow the hawk, and to expose themselves unnecessarily to danger, while, in fact, by their numbers, their perpetual changes of direction, and their uniform endeavour to rise above him, they perplex the hawk to such a degree, that he is unable to fix upon a single object; and, after exerting all his art and address, he is frequently obliged to relinquish the pursuit. When in the extremity of danger, and after employing every other artifice in vain, small birds have been frequently known to fly to men for protection.

The ravens often frequent the sea-shore in quest of food. When they find their inability to break the shells of muscles, &c. they use a very ingenious stratagem: they carry a muscle, or other shell-fish, high up in the air, and then let it fall upon a rock, by which means the shell is broken.

The woodpecker is furnished with a very long and voluble tongue. It feeds upon ants and other



small insects. Nature has endowed this bird with a singular instinct. It knows how to procure food without seeing its prey. It attaches itself to the trunks or branches of decayed trees; and, wherever it perceives a hole or crevice, it darts in its long tongue, and brings it out loaded with insects of different kinds. This operation is certainly instinctive; but the instinct is assisted by the instruction of the parents; for the young are no sooner able to fly, than the parents, by the force of example, teach them to resort to trees, and to insert their tongues indiscriminately into every hole or fissure.

Of the economy of fishes our knowledge is extremely limited. But, as the ocean exhibits a perpetual and a general scene of attack and defence, the arts of assault and of evasion must, of course, be exceedingly various.

The insect tribes, though comparatively diminutive, are not deficient in artifice and address. But, I shall only mention the *formica-leo*, or ant-lion, which is a small insect, somewhat resembling a woodlouse, but larger. Its head is flat, and armed with two fine moveable crotchets or pincers. It has six legs, and its body, which terminates in a point, is composed of a number of membraneous rings. In the sand, or in finely pulverised earth, this animal digs a hole in the form of a funnel, at the bottom of which it lies in ambush for its prey. As it always walks backward, it cannot pursue any insect. To supply this defect, it lays a snare for them, and especially for the ant, which is its favourite food. It generally lies concealed under the sand in the bottom of its funnel or trap, and seldom exhibits more than the top of its head. In digging a funnel, the *formica-leo* begins with tracing a circular furrow in the sand, the circumference of which determines the size of the funnel, which is often an inch deep. After the first furrow is made, the animal traces a se-

cond, which is always concentric with the first. It throws out the sand, as with a shovel, from the successive furrows or circles, by means of its square flat head and one of its fore legs. It proceeds in this manner till it has completed its funnel, which it does with surprising promptitude and address. At the bottom of this artful snare it lies concealed and immoveable. When an ant happens to make too near an approach to the margin of the funnel, the sides of which are very steep, the fine sand gives way, and the unwary animal tumbles down to the bottom. The formica-leo instantly kills the ant, buries it under the sand, and sucks out its vitals. It afterward pushes out the empty skin, repairs the disorder introduced into its snare, and again lies in ambush for fresh prey. When arrived at its full growth, the formica-leo gives up the business of an ensnaring hunter. He deserts his former habitation, and crawls about for some time on the surface of the earth. He at last retires under the ground, spins a round silken pod, and is soon transformed into a fly.

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### No. LXXIII.

#### ON THE INTERNAL STRUCTURE OF THE EARTH.

Sit mihi fas ———

Pandere res altâ terrâ et caligine mersas. VIRGIL.

Give me, ye powers, the wondrous scenes to show  
Concealed in darkness, in the depths below.

ON the surface of our globe, we have contemplated the Divine Power and Goodness, in innume-

rable instances, in which beauty and usefulness are equally apparent. Let us now penetrate into its interior regions, and explore the wonders of creative power in those dark recesses.

The philosopher has extended his *ideal* researches to the very centre of the Earth; but *actual* inquiries have proceeded, hitherto, but a very little depth below its surface; and, even in these inquiries, the spirit of enterprize has been excited more by motives of avarice than of curiosity. The deepest mine, which is that of Cotteberg in Hungary<sup>1</sup>, extends only to the depth of 3000 feet: but what proportion does this bear to the depth of the globe, down to its centre, which is about 4000 miles? Whatever, therefore, has been said of the Earth, to a greater depth, is mere fiction or conjecture. We may suppose it, with Buffon, to be a globe of glass; with Whiston, a sphere of heated iron; with Burnet, a great mass of waters; and, with Kircher, one dreadful volcano; but we must ever, at the same time, confess, that those are suppositions, which can never be ascertained by any human being.

Upon examining the Earth, where it has been opened to any depth, the first things that occur are the different layers or beds of which it is composed. All these lie horizontally over each other, like the leaves of a book, and each of them is composed of materials that increase in weight in proportion as they lie deeper. This is, in general, the disposition of the different materials, where the Earth seems to have been unmolested; but this order is frequently inverted, either from its original formation, or from accidental causes; so that the strata, though nearly parallel, are found much diversified and broken, as to their inclination.

The first layer, most commonly found at the sur-

<sup>1</sup> Boyle, vol. iii, page 240.

face, is that light coat of blackish mould, which is called, by some, garden earth. With this the Earth is universally invested, unless it be washed away by rains, or removed by some other external violence. This seems to have been formed from animal and vegetable bodies decaying, and thus turning into its substance. It serves also as a storehouse, whence the animal and vegetable natures are renewed; and thus are all the vital blessings continued in unceasing circulation. This earth, however, is not to be supposed entirely pure, but is mixed with much stony and gravelly matter, from the layers that lie immediately beneath it. It generally happens, that the soil is fertile, in proportion to the quantity which this putrefied mould bears to the gravelly mixture; and as the former predominates, so far is the vegetation upon it more luxuriant. It is this external covering that supplies man with all the true riches he enjoys. He may bring up gold or precious stones from greater depths; but they are merely the toys of a capricious being, upon which he has placed an imaginary value, and for which he often exchanges the more substantial blessings of life. ‘It is this earth (says Pliny) which, like a kind mother, receives us at our birth, and sustains us when born. It is this alone, of all the elements around us, that is never found an enemy to man. The body of waters may deluge him with rain, oppress him with hail, and drown him with inundations. The air rushes in storms, prepares the tempest, or lights up the volcano; but the earth, gentle and indulgent, ever subservient to the wants of man, spreads his walks with flowers, and his table with plenty; returns with interest every good committed to her care; and if she produce the poison, she supplies also the antidote. Though constantly teased, more to supply the wants of man than his necessities, yet, even to the last, she continues her kind indulgence,

and, when life is over, piously covers his remains in her bosom<sup>1</sup>.

This external and prolific layer is in a state of continual change. Vegetables, which are naturally fixed and rooted to the same place, receive their adventitious nourishment from the surrounding air and water: animals which remove from place to place, are supported by these, or by each other. Both, however, having enjoyed, for a time, a life adapted to their nature, return to the earth those spoils which they had borrowed for a very short space, yet still to be quickened again into existence. But the deposits they make are of very dissimilar kinds, and the earth is differently enriched by their continuance. Those countries that have, for a long time, supported men and other animals, have been observed to become more barren every day; while, on the contrary, those desolate places, in which vegetables only are abundantly produced, are known to be possessed of amazing fertility. ‘In regions which are uninhabited (says Buffon) where the forests are not cut down, and animals do not feed upon the plants, the bed of vegetable earth is constantly increasing. In all woods, and even in those often cut, there is a layer of earth of six or eight inches thick, formed by leaves, branches, and bark, that fall and rot upon the ground. I have frequently observed on a Roman way, which crosses Burgundy, for a long extent, that there is a bed of black earth, of more than a foot thick, gathered over the stony pavement, on which several trees, of a very considerable size, are supported. This I have found to be nothing but the earth formed by the decayed leaves and branches, which have been converted by time into a black soil. Now as vegetables draw much more of their nourishment from the air and water

<sup>1</sup> Hist. Nat. lib. ii. cap. 63.



than they do from the earth, it must follow, that, in rotting upon the ground, they give much more to the soil than they have taken from it. Hence, therefore, in woods kept a long time without cutting, the soil below increases to a considerable depth; and such we actually find in those American wilds where the forests have been undisturbed for ages. But it is otherwise where men and other animals have long subsisted; for, as they make a considerable consumption of wood and plants, both for firing and other uses, they take more from the earth than they return to it. It follows, therefore, that the bed of vegetable earth, in an inhabited country, must be always diminishing, and must, at length, resemble the soil of Arabia Petraea, and other oriental countries, which, having been long inhabited, are now become plains of salt and sand; the fixed salt always remaining, while the other volatile parts have flown away<sup>1</sup>.

If, from this external surface, we descend deeper, and view the Earth cut perpendicularly downward, either in the banks of great rivers, or steepy seashores; or, going still deeper, if we observe it in quarries or mines, we shall find its layers regularly disposed in their proper order. We must not expect, however, to find them of the same kind or thickness in every place, as they differ in different soils and situations. Sometimes, marle is seen to be over sand, and sometimes, under it. The most common disposition is, that under the first earth is found gravel or sand, then clay or marle, then chalk or coal, marbles, ores, sands, gravels; and thus an alternation of these substances, each growing more dense as it sinks deeper. The clay, for instance, found at the depth of one hundred feet, is commonly more heavy than that found near the surface.

<sup>1</sup> Buffon, vol. i. page 353.

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Of these beds over beds it is still more remarkable, that each of them, as far as it extends, maintains exactly the same thickness. It is found, also, that, as we proceed to considerable depths, every layer grows thicker. They are sometimes very extensive, being found often to cover a space of many leagues in circumference. But it must not be supposed, that they are uniformly continued over the whole globe, without interruption: on the contrary, they are ever, at small intervals, cracked through, as were, by perpendicular fissures; the earth resembling, in this respect, the muddy bottom of a pond, hence the water has been dried off by the sun, and thus gaping in several chinks, which descend in a direction perpendicular to its surface. These fissures are many times found empty, but are often closed up by adventitious substances, which the rain or some other accidental causes, have conveyed to their cavities. Their openings are not less different than their contents, some being not above half an inch wide, some a foot, and some several yards asunder; which last form those dreadful chasms that are to be found in the Alps, at the edge of which the traveller stands, dreading to look down to the immeasurable gulf below. These amazing clefts are well known to such as have passed those mountains, where a chasm frequently appears several hundred feet deep, and as many over, at the edge of which the way lies. It often happens also, that the roads lead along the bottom, and then the spectator observes, on each side, frightful precipices several hundred feet above him; the sides of which correspond exactly with each other, that they seem evidently torn asunder.

But the chasms in the Alps are nothing to what are to be seen in the Andes in America. These amazing mountains, in comparison of which the former are but little hills, have their fissures in pro-

portion to their magnitude. In some places, they are a mile wide, and deep in proportion; and there are some others, that running under ground, resemble, in extent, a province<sup>1</sup>.

Of this kind also is the cavern called Elden Hole in Derbyshire; which, Dr. Plott tells us, was sounded by a line of 2800 feet, without finding the bottom, or meeting with water; and yet the mouth of it is not above forty yards over<sup>2</sup>. This immeasurable chasm runs vertically downward; and the sides of it seem to tally so correctly, as to show that they were once united. Those who visit the chasm generally procure stones to be thrown into its mouth; and these are heard for some time, falling and striking against its sides, producing a sound like distant thunder, dying away as the stone falls deeper.

There are many more of these dreadful perpendicular fissures in different parts of the Earth, with accounts of which Kircher, Gaffarellus, and others, who have given histories of the wonders of the subterranean world, abundantly supply us. The generality of readers, however, will consider them with less astonishment, when they are informed of their being common all over the Earth; that in every field, in every quarry, these fissures are to be found; either still gaping, or filled with matter that has accidentally closed their interstices. The inattentive spectator neglects the inquiry; but their being common is partly the cause that excites the philosopher's attention to them. The irregularities of Nature he is often content to pass over unexamined; but when a constant and common appearance is presented, every return of the object is a fresh call to his curiosity, and the chink in the next quarry becomes as great a matter of wonder as the

<sup>1</sup> Goldsmith's *History of the Earth*, vol. i. ch. 6.

<sup>2</sup> *Philosophical Transactions*, vol. ii. page 370.

chasm in Elden Hole. Philosophers, therefore, have long endeavoured to find out the cause of these vertical fissures, which our own countrymen, Woodward and Ray, were the first who observed to be so common and universal. Buffon supposes them to be cracks made by the sun, in drying up the earth, immediately after its emerging from the deep. The heat of the sun is very probably a principal cause; but it is not right to ascribe to one cause only, what we find may be the result of many causes. Earthquakes, severe frosts, bursting waters, and storms tearing up the roots of trees, have produced them in our own times; and to this variety of causes we must, at present, be content to ascribe those which have happened at remote periods, before we could have the opportunity of making any observations upon them.

But in surveying the subterranean wonders of the globe, beside those fissures that descend vertically, we frequently find others that descend but a little way, and then spread themselves often to a great extent below the surface. Many of these caverns, it must be confessed, may be the production of human art and industry; retreats made to protect the oppressed or shelter the robber. Such, for instance, are the famous labyrinths of Candia; the stone quarry of Maestricht; the salt mines in Poland; some of the catacombs in Egypt and Italy; and a great number of artificial caverns in Spain, that were made to serve as retreats for the Christians against the fury of the Moors. But the greatest number of caverns have been fashioned by the hand of Nature only. Indeed, there is scarcely a country in the world without its natural caverns; and, every day, many new ones are discovered. Of those in England, Oakey-hole in Somersetshire, the Devil's-hole in Derbyshire, and Penmark-hole in Gloucestershire, have been often described. The former

lies on the south side of Mendip-hills, about a mile from the city of Wells. To conceive a just idea of this, we must imagine a precipice of more than one hundred yards high, on the side of a mountain, which shelves away a mile above it. In this is an opening not very large, into which we enter, going along upon a rocky uneven pavement, sometimes ascending, and sometimes descending. The roof of it, as we advance, grows higher, and, in some places, is fifty feet from the floor. In some places, however, it is so low, that a man must stoop to pass. It extends, in length, about two hundred yards; and from every part of the roof, and the floor, there are formed sparry concretions of various figures, which by strong imaginations have been likened to men, lions, and organs. At the farthest part of this cavern rises a stream of water, well stored with fish, large enough to turn a mill, and discharging itself at the entrance.—But of all the subterranean caverns now known, the most remarkable is the Grotto of Antiparos, discovered in the island of that name, by Magni, an Italian traveller. The descriptions of this, by Kircher, Tournefort, and the count de Choiseul Gouffier, are too long to be inserted, but are highly deserving the attention of the inquisitive traveller, who visits these subterraneous scenes for amusement only, and the more minute observation of the philosopher, ardent to pursue Nature to her most secret recesses.

It is here natural to inquire how these amazing hollows of the earth came to be formed. It seems evident to a philosopher who would attend to the account of Oakey-hole, and to the descriptions that have been given of the other caverns I have mentioned, that their excavation has been occasioned by streams of water; which finding subterranean passages, and by degrees hollowing the beds in which they flowed, the ground above them has slipped



down closer to their surface, leaving the upper layers of the earth or stone still suspended: the ground that sunk upon the face of the waters forming the floor of the cavern; the ground, or rock, that kept suspended, forming the roof. Indeed, there are but few of these caverns found without water, either within them, or near enough to point out their formation.

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## No. LXXIV.

## ON EXTRANEOUS FOSSILS.

There are more things in heaven and earth  
Than are dreamt of in our philosophy.

SHAKESPEARE.

THE origin of greater part of the subterranean curiosities is involved in such impenetrable obscurity, that the philosopher, in his most profound reasonings, as well as the poet, in his ideal excursions, may justly imagine, that creation at large abounds with innumerable objects, of which the most laborious inquirers into nature have hitherto formed no conception. Among these subterranean wonders, that division of fossils which is denominated *extraneous*, has employed the curiosity of several of our latest naturalists.

The word Fossil is used, in a general sense, for any thing dug out of the Earth, as metals, stones, salts, earths, and other minerals, which are called *native* fossils; or for any thing deposited in the bowels of the Earth, by any extraordinary means,

as earthquakes, the deluge, &c. and these, to which I shall confine my observations in this paper, are denominated *extraneous*. They include the subterranean exuviae of marine and terrestrial animals, and even vegetables; as shells, bones, teeth, trees, plants, leaves, stalks, &c. which are found buried, in great abundance, in various parts of the globe. Our naturalists have each their several system, to account for these extraneous fossils; in particular, for the surprising appearance of petrified sea fishes, in places far remote from the sea, and on the summits of the highest mountains; of shells in the middle of quarries of stone or marble; of the teeth of elephants; of the bones of divers animals peculiar to the southern climates; and of plants growing only in the east, which are found fossil in our northern and western parts.

Dr. Lister was of opinion, that these shells, &c. were real stones, and stone plants, formed after the usual manner of other figured stones. But a variety of considerations soon satisfied the naturalist, that this doctrine was erroneous. Another opinion is, that the fossil shells, with all other extraneous bodies found within the earth, were buried therein at the time of the universal deluge. Dr. Woodward<sup>1</sup>, in particular, pursuing and improving the theory of Dr. Burnet<sup>2</sup>, maintained, that the whole mass of earth, with every thing belonging to it, was so broken and dissolved, at the time of the deluge, that a new earth was then formed in the bosom of the water, consisting of different strata, or beds of terrestrial matter, ranged over each other, usually in the order of their specific gravities. Thus plants, animals, and especially fishes, and shells, not yet

<sup>1</sup> Woodward's Essay toward a Natural History of the Earth.

<sup>2</sup> Burnet's Sacred Theory of the Earth.

dissolved among the rest, remained mixed and blended among the mineral and fossil matters; which preserved them, or at least assumed and retained their figures and impressions, either indentedly, or in relievo.

Camerarius, a learned German, attacked the opinion of Dr. Woodward; and the celebrated count Buffon, and the ingenious Mr. Whitehurst, have adopted a very different theory. "The surface of the earth (says this philosopher) must have been, in the beginning, much less solid than it is at present; and, consequently, the same causes, which at this day produce but very slight changes, must then, upon so complying a substance, have had very considerable effects. We have no reason to doubt but that it was then covered by the waters of the sea, and that those waters were above the tops of the highest mountains, since, even in such elevated situations, we find shells, and other marine productions, in very great abundance. It appears also, that the sea continued, for a very considerable time, upon the face of the earth; for, as these layers of shells are found so very frequently at such great depths, and in such prodigious quantities, it seems impossible for such numbers to have been supported all alike at one time; so that they must have been brought there by successive depositions. These shells also have been found in the bodies of the hardest rocks, where they could not have been deposited, all at once, at the time of the deluge, or at any such instant revolution; since that would be to suppose, that all the rocks in which they are found were, at that instant, in a state of dissolution, which it would be absurd to assert. The sea, therefore, deposited them wheresoever they are now to be found, and that by slow and successive degrees.—It will appear, also, that the sea covered the whole earth, from the appearance of its layers,

which lying regularly one above the other, seem all to resemble the sediment formed at different times by the ocean. Hence, by the irregular force of its waves, and its currents driving the bottom into sandbanks, mountains must have been gradually formed within this universal covering of waters; and these successively raising their heads above its surface, must, in time, have formed the highest ridges of mountains upon land, together with continents, islands, and low grounds, all in their turn. This opinion will receive additional weight by considering, that in those parts of the earth where the power of the ocean is greatest, the inequalities on the surface of the earth are highest. The power of the ocean is greatest at the equator, where its winds and tides are most constant; and, in fact, the mountains at the equator are found to be higher than in any other part of the world. The sea, therefore, has produced the principal changes in our earth: rivers, volcanos, earthquakes, storms, and rain, having made but slight alterations, and such only as have affected the globe to very inconsiderable depths<sup>1</sup>.

<sup>1</sup> *Theorie de la Terre*, vol. i. page 111. Goldsmith, who, although his authority is not to be depended upon, has often some beautiful observations, speaking of Buffon's Theory of the Earth, says, 'A thousand questions might be asked this most ingenious philosopher, which he would not find it easy to answer; but such is the lot of humanity, that a single Goth can in one day destroy the fabric which Cæsars were employed an age in erecting. We might ask how fossil-wood is found deeper than shells; which argues, that trees grew upon the places which he supposes once to have been covered by the ocean?' *History of the Earth*, vol. i. page 36. Edit. in 12mo. And again, in page 45, he thus expresses himself: 'But while there are many reasons to persuade us, that these extraneous fossils have been deposited by the sea, there is one fact that will abundantly serve to convince us, that the earth was habitable, if not inhabited, before these marine substances came to be thus deposited; for we find fossil trees, which, no doubt, once grew upon the earth, as deep, and as

Mr. Whitehurst has given a very copious account of the various phenomena relative to the *exuvie* of marine animals, collected from the observations of Buffon, and other eminent naturalists, as well as from those which have occurred, in the course of his own inspection, in various parts of England. I shall extract the substance of these, for the information of the curious reader, and then proceed to state the doctrine which he deduces from the whole.

Fossil shells are found in the Alps, and, in general, in all the elevated places of Europe; in most of the quarries of stone and marble in Italy; and in the stones of which the most ancient edifices of the Romans were constructed. In Switzerland, Asia, and Africa, petrified fish have been observed in many places; for instance, on the mountains of Castravan, there is a bed of white laminated stone: and each *lamina* contains a great number and diversity of fishes; for the most part very flat, and extremely compressed, in the manner of fossil fern; yet so well preserved, that the most minute marks of their fins and scales are distinguishable, and every other part by which one species of fish is known from another. The teeth of sharks, and of other

much in the body of solid rocks, as these shells are found to be. Some of these fallen trees, also, have lain at least as long, if not longer, in the earth, than the shells, as they have been found sunk deep in a marly substance, composed of decayed shells, and other marine productions. M. Buffon has proved, that fossil shells could not have been deposited in such quantities all at once by the flood; and I think, from the above instance, it is pretty plain, that howsoever they were deposited, the earth was covered with trees before their deposition, and, consequently, that the sea could not have made a very permanent stay. How then shall we account for these extraordinary appearances in nature? A suspension of all assent is certainly the first, although the most mortifying conduct, &c.



fishes, are found in the jaws, polished and worn smooth at the extremities, and which, consequently, must have been made use of, during the life of the animal: and, in the shells, the very pearls are found, which the living animals of the same kind produce.

It is well known, that the *purpura* and *pholades* have a long pointed proboscis, which serves them as a kind of gimblet or drill, to pierce the shells of living fish, on whose flesh they feed. Now, shells thus pierced are found in the earth, which is another incontestable proof, that they heretofore inclosed living fish, and that these fish inhabited places where the *purpura* and *pholades* preyed upon them.

In the Alps and Pyrenean mountains shells are found under beds of stone, a hundred, and even a thousand feet below the surface of the earth; and not merely those which are testaceous, but the relics of the crustaceous fishes also, and even all marine productions. Mr. Whitehurst, moreover, is of opinion, that in the generality of marbles there is so great a quantity of marine productions, that they appear to surpass in bulk the matter by which they are united.

Among the many instances of the multiplicity of oysters, there are few more extraordinary than that immense bed, of which M. Reaumur gives an account, which contains 130,630,000 cubic fathoms. This vast mass of marine bodies is in the Touraine in France, above thirty-six leagues from the sea. Some of these shells are found so entire, that their different species are very distinguishable. Some of the same species have been recently found on the coast of Poitou, and others are known to be natives of more distant parts of the world. Among them are likewise blended some fragments of the more stony

kinds of sea productions, such as *madrepores*, *fungi marini*, &c. The Touraine contains full nine square leagues in surface, and, wherever it is dug, furnishes these fragments of shells.

Mr. Whitehurst observes, that we shall be less astonished at this very considerable quantity of shells, when we consider the vast increase of shell-fish. It is not uncommon to take away a bed of these shell-fish, several fathoms in thickness; and although the places where they are fished for appear to be entirely exhausted, yet, in the ensuing year, as many will be found in all these places as before.

Hardell Cliff, in Hampshire, contains a great variety of turbinated and bivalve shells, which still retain the native matter and colour of marine shells. Many of these are natives of very distant regions; and others of them are not known to exist in a living state. In some parts of Suffolk, shells are so numerous, that they are dug up for manure, and produce excellent crops.

Within ten yards of the summit of Naphat, a remarkable mountain in Ireland, elevated several hundred fathoms above the level of the sea, are many vast beds of marine shells of various kinds, as whelks, muscles, cockles, &c. In Derbyshire and Staffordshire, Mr. Whitehurst frequently observed, with astonishment, enormous masses of limestone composed almost entirely of fossil shells, or other marine relicks, diffused throughout the solid substance of the strata. The isle of Shepy, in Kent, contains not only the teeth of sharks, and the bones of fish, but such a great variety of fossil bodies belonging both to the animal and vegetable kingdoms, as evidently show it to be an assemblage of adventitious matter. In fine, the remains of marine animals imbedded in the solid substance of stone, chalk, and clay, and in sand, gravel, &c. in all parts of the known world, are so extremely numerous, that

it is quite unnecessary to add any more instances of the kind<sup>1</sup>.

Mr. Whitehurst, in collecting together these, and many other curious facts, relative to fossil bodies, does not appear to have had any intention to point out the faults of other systems, but to avail himself of such parts of them as were applicable to his own design; namely, 'to trace appearances in nature from causes truly existent, and to inquire after those laws by which the Creator chose to form the world, not those by which he might have formed it, had he so pleased.'—In consequence of this design, having given a very copious and scientific account of the general phenomena of fossil bodies, he has deduced from them the following inferences.

First, The great analogy in the figure, colour, and consistence of fossil bodies, to the shells, bones, and teeth of living fish, together with a gradual change in their component parts, from a testaceous, to a stony metallic substance, evidently shows, that all such fossil bodies were originally productions of the sea.

Secondly, Their being found in all parts of the world, even imbedded in the highest mountains, as well as in valleys, and deep recesses of the earth, remote from the sea, evidently shows that the sea prevailed universally over the earth<sup>2</sup>; and, consequently, that these marine animals were created prior to the primitive islands<sup>3</sup>, and likewise prior to

<sup>1</sup> For a great variety of particulars on this interesting subject, the curious reader is referred to Mr. Whitehurst's *Inquiry into the Original State and Formation of the Earth*, chap. vii. He should also, since this is a branch of knowledge which is daily receiving fresh accessions and modifications, peruse the articles *Geology* and *Oryctology*, in the *Pantologia*, and Parkinson's *Organic Remains of a former World*.

<sup>2</sup> See *Inquiry*, ch. v.

<sup>3</sup> *Ib.* ch. vi.

terrestrial animals, agreeably to the scripture account of the creation.

Thirdly, And since they are found at various depths in the earth, even to that of several thousand feet, and in different states of decay, and variously impregnated with stony or metallic matter, and even changed into the substance of the stone in which they are imbedded; it evidently appears, that the strata were originally in a state of fluidity, and that they were thus entombed and deprived of life, in successive periods of time.

Fourthly, the beds of fossil shells which consist of one species only, and are not native of the climate where found, but of very distant regions of the earth, evidently show that they were generated, and have lived and died, in the very beds where found, and could not have been removed from their native climate by a flood, or floods of water, with so much order, as to form beds consisting of only one select species; and, therefore, all such beds must have been originally the bottom of the ocean.

Such are the inferences which Mr. Whitehurst has deduced from the interesting facts he has collected; which tend to corroborate, he observes, the several results arising from the former parts of his 'Inquiry into the Original State and Formation of the Earth:' namely, that the earth was originally a fluid chaotic mass, totally unfit for animal or vegetable life: that it was progressively formed into a habitable world: that marine animals were created prior to the primitive islands, and consequently prior to terrestrial animals; that they were entombed in the bowels of the earth, in successive periods of time, and before dry land appeared. These inferences, however, have been questioned by more recent geologists, who, in their turn, have advanced notions fully as liable to objection. Time and mul-

multiplied inquiries in every direction, are requisite to the formation of an unobjectionable theory.

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No. LXXV.

ON THE MINERAL PRODUCTIONS OF  
THE EARTH.

Æs atque aurum, ferrumque repertum est,  
Et simul argenti pondus plumbique— LUCRET.

Then brass, and gold, and iron ore, were found,  
And pond'rous lead and silver pressed the ground.

IN my last two papers, I have conducted my readers into the interior regions of our globe: I have treated of its wonderful natural fissures and caverns, the disposition of the different kinds of earths, and the nature and origin of that part of fossil productions, which we denominate *extraneous*. I have been hitherto accompanied by the philosopher, not the poet: in treating, however, of mines, and their productions, which I have already noticed as *native* fossils, I find more than one poetical invitation:

Through dark retreats pursue the winding ore,  
Search Nature's depths, and view her boundless store;  
The secret cause in tuneful numbers sing,  
How metals first were framed, and whence they spring:  
Whether the active sun, with chymic flames,  
Through porous earth transmits his genial beams;  
With heat impregnating the womb of night,  
The offspring shines with its paternal light:—



Or whether, urged by subterraneous flames,  
 The earth ferments, and flows in liquid streams;  
 Purged from their dross, the nobler parts refine,  
 Receive new forms, and with fresh beauties shine :—  
 Or whether by creation first they sprung,  
 When yet unpoised the world's great fabric hung:  
 Metals the basis of the earth were made,  
 The bars on which its fixed foundation's laid:  
 All second causes they disdain to own,  
 And from th' Almighty's fiat sprung alone. YALDEN.

And now the regions deep explore,  
 Where metals ripen in vast cakes of ore.  
 Here, sullen to the sight, at large is spread  
 The dull unwieldy mass of lumpish lead.  
 There, glimm'ring in their dawning beds, are seen  
 The light aspiring seeds of sprightly tin.  
 The copper sparkles next in ruddy streaks.

The silver then, with bright and burnished grace,  
 Youth and a blooming lustre in its face,  
 To th' arms of those more yielding metals flies,  
 And in the folds of their embraces lies. GARTH.

In treating this subject philosophically, it is requisite first to mention mines, those artificial excavations, in which metals, minerals, or even precious stones, are dug up. These mines obtain various denominations, because the matter, or substances, dug out of them, is various. Thus, there are gold-mines, silver-mines, copper-mines, lead-mines, tin-mines, iron-mines, diamond-mines, mines of antimony, of alum, &c.

The richest and most celebrated gold and silver-mines are those of Peru and Chili, in South America. Iron-mines are more abundant in Europe than elsewhere. Copper-mines are chiefly found in Sweden, Denmark, and England; and lead and tin-mines in England; the latter, more particularly in the county of Cornwall. Quicksilver-mines abound principally in Hungary, Spain, Friuli in the Venetian territories, and Peru; diamond-mines, in the

East Indies, and in the Brazils; and salt-mines in Poland.

The word *mineral* is sometimes used in the general for *fossil*, and is applied to any substance, simple or compound, dug out of a subterraneous place or *mine*; from which it takes the denomination. In this sense, metals, sulphurs, fossil salts, semi-metals, &c. are minerals. On this principle, minerals are divided into two classes; the one *fusible* and *malleable*, that is, which melt with fire, and stretch on the anvil: which are what we properly call *metals*. The other class want these two properties, and are what in the strictest sense we call *minerals*.

According to some, minerals may be divided into *simple* and *compound*. To the first belong stones; salts, as alum, nitre, &c. inflammable minerals, as sulphur and bitumen; and metals, as platinum, gold, &c. Other more accurate writers restrain the word mineral to what we otherwise call *semi-metals*, as antimony, cobalt, &c.

The word mineral, in this sense, may be defined a compound fossil, in which something is discovered in all respects like metal, only that it is not malleable; joined or compounded with some other fossil, as salt, sulphur, stone, or earth. Such are antimony, cinnabar, bismuth, calaminaris, vitriol, pyrites, marcasites, cobalt, oker, the magnet, lapis hæmatites, and armenus.

Of the origin of minerals there are various opinions. Some philosophers attribute the formation of them to the action of the sun without: some, to the influence of the central fire within; and some think that cold is the productive cause, by uniting, condensing, and congealing certain juices of the earth.

To the first two opinions Dr. Yalden alludes in the lines quoted above; and Thomson, in his beautiful Hymn to the Sun, extends the penetrating influence of that luminary, not to the formation of

O. LXXV. *Mineral Productions of the Earth.* 341

etals only, but to the production also of the precious stones :

Nor to the surface of enlivened earth,  
Graceful with hills and dales, and leafy woods,  
Her liberal tresses, is thy force confined :  
But to the bowelled cavern darting deep,  
The mineral kinds confess thy mighty power.  
Effulgent, hence the veiny marble shines ;  
Hence Labour draws his tools ; hence burnished War  
Gleams on the day ; the nobler works of Peace  
Hence bless mankind, and generous Commerce binds  
The round of nations in a golden chain.

Th' unfruitful rock itself, impregn'd by thee,  
In dark retirement forms the lucid stone.  
The lively diamond drinks thy purest rays,  
Collected light, compact ; that, polished bright,  
And all its native lustre let abroad,  
Dares, as it sparkles on the fair-one's breast,  
With vain ambition emulate her eyes.  
At thee the ruby lights its deepening glow,  
And with a waving radiance inward flames.  
From thee the sapphire, solid ether, takes  
Its hue cerulean ; and, of evening tinct,  
The purple-streaming amethyst is thine.  
With thy own smile the yellow topaz burns ;  
Nor deeper verdure dies the robe of Spring,  
When first she gives it to the southern gale,  
Than the green emerald shows. But, all combined,  
Thick through the whitening opal play thy beams ;  
Or, flying several from its surface, form  
A trembling variance of revolving hues,  
As the site varies in the gazer's hand.

Descartes was of opinion that metals were formed from the beginning of the world, and were ranged, by the laws of gravity, about the centre. These he supposes to have been corroded, in process of time, by the acid salts, &c. and abundance of their parts carried up along with these salts by the subterranean heat, and deposited in various parts of the earth.—M. Tournefort supposes seeds of minerals, as well as of animals and vegetables. According to this celebrated botanist, every thing, stones not excepted,

comes from eggs; and the most prodigious rocks, he thinks, were originally no more than grains of sand. The alchymists maintain, that metals proceed from a certain *primum ens*, or first seed of metals, which, they say, is a kind of moist vapour, or gas, that changes the earth or juice it meets with in a vein into a mineral body or substance, and thence converts the minerals into ores or metals, by a continued fermentation or elaboration in the mines, caused by the *archeus*, or heat that acts in the veins, as it proceeds from the centre of the earth. But this doctrine of mineral fermentation is positively denied by the great Boerhaave, who, in his History of Fermentation, asserts, that it belongs to the vegetable kingdom only. Others maintain, that all metals and minerals were originally created in the very same state and nature in which they are ever found, without undergoing any kind of alteration. The most common opinion, among the miners of Cornwall, is, that crude immature minerals nourish and feed the ores with which they are intermixed in the mines; and that the minerals themselves will, in process of time, be converted into ores productive of those metals to which they have the nearest affinity, and with which they have the greatest intercourse.

M. Geoffrey and others contend, that metals, &c. may be the result of a mixture of certain matters, which had nothing metallic in them. Thus, in the ashes of all vegetables, we find a ferruginous matter, which the loadstone attracts; and yet it can hardly be said that iron existed in the plants. We see no signs of iron in clay, in whatever manner it may be worked; and yet, let linseed-oil be added to it, and by fire iron may be procured. The same may be said of many other substances. It is probable, therefore, that metals may be formed by a combination of different ingredients; much like sulphur, which is known to be made by adding an inflammable prin-

ciple to a vitriolic salt. Our globe may abound every where with those matters, which are continually circulating through its pores and canals, and which, meeting with an earth homogeneous to them, fix thereto, and commence minerals.

Mr. Price, in his *Mineralogia Cornubiensis*, thinks it most reasonable to conclude, that metals were made and planted in veins, at, or very soon after the creation of the world: but that they are subject to a degree of fluctuation in common with all other matter, approaching to, or receding from, their ultimate degree of perfection, either quicker or slower, as they are of greater or less solid and durable frame and constitution. He supposes, that in every metal there is a peculiar magnetism, and an approximation of particles, *sui generis*, by which its component principles are drawn and united together; particularly the matters left by the decomposition of the waters passing through the contiguous earths or *strata*, and deposited in their proper *nidus* or receptacle; till by the accretion of more or less of its homogeneous particles, it may be denominated either rich or barren.

The minerals, metals, and stones, lie in beds; and have done so ever since the flood, if not from the creation. But it is highly probable that they have a faculty of growing in their respective beds, and that, as the beds are robbed and emptied by miners, so, after a while, they recruit again. Thus vitriol, Mr. Boyle thinks, may grow by the help of the air, and that alum does the same. 'We are assured (says this excellent philosopher) by the experienced Agricola, that the earth or ore of alum, being robbed of its salts, will, in tract of time, recover them again, by being exposed to the air.'

There is great reason to believe that metals likewise grow, from what has been alleged by Mr. Boyle in his observations about the growth of metals, and particularly as to the growth of iron. To the ill-



stances he brings from Pliny, Fallopius, Cesalpinus, and others, we may add, that in the forest of Dean, in Gloucestershire, the best iron, and in the greatest quantities, is found in the old cinders, which they melt over again. This is imputed by some to the negligence of the former melters in not exhausting the ore; and Dr. Derham thinks it rather owing to the new impregnations of the old ore, or cinders, from the air, than to any seminal principle in the ore itself. There are some other facts however, which it is proper to mention here, although they are not all equally well attested. In some mines, it is said, the metals are found, at their first opening, very crude and imperfect; but which, nevertheless, in process of time, grow ripe and rich. Alonzo Barba relates, that, in Potosi, stones have frequently been thrown aside, as not containing any thing considerable of metal, and yet have been found exceedingly full of it, many years afterward. Cesalpinus assures us, that earths, which before yielded no metal at all, sometimes became very fertile veins; and, in an island of the Tyrrhene sea, after the iron mines have been exhausted, they stop working them about ten years; at the expiration of which, it is said, they are found as rich as before.

This subject would lead me beyond my limits; I shall therefore conclude this paper with some general observations on the mineral kingdom.

It is utterly impossible for a being endowed like man, with such a limited understanding, to embrace at one view the universal reign of Nature, and to comprehend, in their entire extent, the wonderful properties of every object. We must be content to acquire an imperfect knowledge of Nature, by examining, from time to time, some isolated objects, some particular beauties, but with as much attention as possible to a successive order and arrangement, *without which* our studies would be desultory and

uninstructive. Let us confine our attention, at present, to some of the most striking phenomena of the mineral kingdom.

Among stones there is not one that deserves more attention than the magnet, but of this I have already treated in a former paper<sup>1</sup>.

Properties equally wonderful are to be found in quicksilver. It yields to every form we may choose to give it; but it never fails to resume that which is natural to it. Exposed to the fire, it ascends in fume. By a chemical process it may be converted into a hard and transparent crystal; but it may be reduced again to its original fluidity. Its uses in medicine, in the barometer, in looking-glasses, in gilding, &c. are well known. But a minute account of all its properties would fill a volume.

Gold is the principal and most valuable of all the metals, not only on account of its scarcity, but of its many admirable properties. Of all bodies it is the most tenacious and unalterable; insomuch that it will bear the action of the most violent fire for two months, without any sensible diminution of its weight. Its parts are so subtle, that a grain of leaf gold can be made to cover fifty square inches; so that upon the two surfaces, on a slight inspection, may be distinguished four millions of parts. And its ductility is such, that from a single grain may be drawn a wire five hundred feet long.

The wonderful form of common salt, the precious stones, the singular shapes of the ores, or metals in their mineral state, the astonishing particulars we have already noticed of extraneous fossils, and a variety of inexhaustible objects of inquiry in the mineral kingdom, seem constituted, with the other wonders of creation, to excite our curiosity. And it must be confessed, that there is not an employment

<sup>1</sup> No. LII, On Magnetism and the Mariner's Compass.

of the mind productive of greater delight, of more solid satisfaction, or of a greater variety of enjoyment, than an attentive contemplation of the works of Nature. Were we to live for ages in this world, and to employ every day in studying the singularities of the mineral kingdom only, we should still find innumerable things which we could not explain, which would excite more and more our curiosity, and yet continue inscrutable by our finite capacities. Let us employ then, at least, since the duration of our lives scarcely extends beyond half a century, let us well employ the short time that is granted to us here, and devote as much of it as the necessary duties of life will permit, to the study of Nature ; and, by thus enriching our minds, treasure up the most innocent and the most inexhaustible stores of knowledge and pleasure. The exquisite delight which such studies afford, will be heightened more and more, in proportion as we meditate on the ends which the Creator has proposed in his works ; for the wonders of Nature are more admirable and more sublime than all the productions of human art. These are not always compatible with our welfare ; and, so far from rendering us either wiser or better, they are often the mere objects of uninstrusive admiration. But all the works of Nature, even the most singular and inexplicable, have for their object the felicity of the whole creation. They exist, not merely to be contemplated as objects of sight, but to be enjoyed ; and all, without exception, proclaim unspeakable goodness, as well as unsearchable wisdom and unbounded power.

Oh, Nature, all-sufficient, over all !  
 Enrich me with the knowledge of thy works !  
 Snatch me to heaven ; thy rolling wonders there,  
 World beyond world in infinite extent,  
 Profusely scattered o'er the blue immense,  
 Show me ; their motions, periods, and their laws,

Give me to scan ; through the disclosing deep  
 Light my blind way ; *the mineral strata there* ;  
 Thrust, blooming, thence the vegetable world ;  
 O'er that the rising system, more complex,  
 Of animals ; and higher still, the mind,  
 The varied scene of quick-compounded thought,  
 And where the mixing passions endless shift ;  
 These ever open to my ravished eye ;  
 A search the flight of time can ne'er exhaust !

THOMSON.

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 No. LXXVI.

## ON MOUNTAINS.

So pleased at first the towering Alps we try,  
 Mount o'er the vales, and seem to tread the sky ;  
 Th' eternal snows appear already past,  
 And the first clouds and mountains seem the last ;  
 But, those attained, we tremble to survey  
 The growing labours of the lengthened way,  
 Th' increasing prospect tires our wandering eyes,  
 Hills press o'er hills, and Alps on Alps arise. POPE.

EMERGING from the vast abysses of the earth, we proceed once more to contemplate its external appearance in all its picturesque and pleasing, or magnificent and tremendous varieties. Mountains are the first objects that strike the imagination, and excite our curiosity, in the wonderful prospect before us. There is nothing in all nature, perhaps, that can impress a spectator, unaccustomed to these views, with such ideas of solemnity and awe as the stupendous piles of Nature, before which the proudest monuments of human art dwindle into minuteness and insignificance.

In countries where there is nothing but plains, the smallest elevations are apt to excite our wonder.

In Holland, the whole surface of which is flat, a little ridge of hills is shown, near the sea-side, which the great Boerhaave generally mentioned to his pupils as mountains of no small consequence. But what would be the sensations of such an audience, could they be presented at once with a view of the heights and precipices of the Alps or of the Andes! Even in this island we have no adequate ideas of a mountain prospect. Our hills are generally sloping from the plain, and clothed to their very summits with verdure. It is scarcely possible, therefore, to exalt our conceptions to those immense piles, whose tops faintly appear behind intervening clouds, sharp and precipitate, and soar to heights which human avarice or curiosity have never been able to ascend:

Rocks rich in gems, and mountains big with mines,  
That on the high equator ridgy rise,  
Whence many a bursting stream auriferous plays.

THOMSON.

The *origin* of mountains is a subject which has given rise to many philosophical disquisitions. Burnet, Whiston, Woodward, and Buffon, have endeavoured to account for them in their respective theories of the earth. Mr. Ray, M. le Cat, and M. Pallas, have likewise their systems. But the most satisfactory account, in my opinion, is that given by Mr. Whitehurst, in his *Inquiry into the Original State and Formation of the Earth*. According to this excellent philosopher (who, instead of speculative inquiries in the closet, descended into the bowels of the earth in quest of *data* from which we might draw just or probable inferences) the antediluvian world was very different from that which we contemplate at present. It consisted only of small islands gradually rising from the deep; or of smooth, even, and uniform elevations: whereas the world on which we tread at present consists of immense continents and moun-



tains, of steep or impending shores, craggy rocks, and extensive valleys and caverns. Our marine *exuvia* formerly lay at the bottom of the ocean of the primitive world; whereas many of them are now situate near the tops of those immense mountains, the Alps and the Andes, and at great distances from the sea. To account for so great a revolution, Mr. Whitehurst has collected many instances from history of stupendous changes that have been produced on the surface and in the bowels of the earth. He enumerates some of the more striking examples of the rising of islands, such as Santorini, Hiera, &c. from the bottom of the sea, attended with *eruptions of fire*. He mentions several islands and mountains having volcanic appearances, and which may likewise be supposed to owe their origin to the same cause, in times anterior to all history. Such are Iceland, Fayal, &c. in the northern sea; St. Helena and Ascension islands, between Africa and Brazil; Easter or Davis' island, Otaheite, &c. in the Southern Ocean; several of the Moluccas, in the Indian Sea; Madeira, several of the Azores and the Antilles, &c. in the Atlantic Ocean; the Lipari islands, Ischia, &c. in the Mediterranean. After collecting many instances of mountains formed, and large districts of land swallowed up, shattered, and rent asunder by earthquakes, and particularly by volcanos, he observes that we may, by analogy, be justified in inferring, that all similar appearances may have been the effects of the same cause; and though vestiges of volcanos are not every where visible, the earth exhibits indications of their having existed in so many different regions, that there is reason to suppose that subterraneous fire must, at different times, have existed universally in its bowels. He then proceeds to show that this cause, acting on a larger scale, produced, at the same time, the immense continent and mountains in the present globe and the universal deluge.

When Mr. Whitehurst ascribes these great phenomena to *fire*, it must be understood that he means, in general, the united actions of fire and water; or the expansive power of the latter when converted into *steam*, or an elastic vapour, by means of heat; a force which is indeed enormous, and which has been lately calculated, from actual experiments, to exceed even that of gunpowder, in the proportion of 140 to 5.

Fire, acting alone at first, and with an intensity gradually increasing on the superincumbent *strata*, Mr. Whitehurst supposes to have gradually distended and elevated those parts most, on which the antediluvian ocean rested, as the primitive islands, by their additional weight of solid and heavy matter, opposed a greater resistance. The waters thus raised would naturally flow toward the now less elevated solid parts, or antediluvian islands; and would finally cover them, so as to produce a *universal deluge*.

The expansion caused by fire increasing, till its force became superior to the gravity, and cohesion, or tenacity, of the incumbent *strata*; the latter would at length burst, and through the fissures a communication would be opened between the water and the ignited melted matter below. By the steam thus suddenly generated, explosions would ensue, which must destroy the uniformity of the globe, shatter it into fragments, produce immense mountains, and extensive and deep subterraneous caverns; into which last the waters would afterward descend, and leave the various continents, mountains, &c. in nearly the same state in which we now view them; and containing the same shells, and other marine *exuvia* which they brought up with them from the bottom of the sea.

‘The terraqueous globe (says Mr. Whitehurst) being thus burst into millions of fragments, and from a cause apparently seated nearer to its centre

than its surface, must certainly have been thrown into strange heaps of ruins: for the fragments of the *strata*, thus blown up, could not possibly fall together again into their primitive order and regularity: therefore an infinite number of subterraneous caverns must have ensued at the distance of many miles, or many hundreds of miles below the bottom of the antediluvian sea.

‘ Now it is easy to conceive, when a body of such an immense magnitude as the earth, which is nearly 8000 miles in diameter, was thus reduced to a heap of ruins, that its incumbent water would immediately descend into the cavernous parts thereof; and by thus approaching so much nearer toward the centre, than in its antediluvian state, much of the terrestrial surface became naked and exposed, with all its horrid gulfs, craggy rocks, mountains, and other disorderly appearances.

‘ Thus, the primitive state of the earth seems to have been totally metamorphosed at the first convulsion of Nature, at the time of the deluge; its *strata* broken, and thrown into every possible degree of confusion and disorder. Hence, those mighty eminences the Alps, the Andes, the Pyrenean, and all other chains of mountains, were brought from beneath the great deep. Hence, the sea retired from those vast tracts of land, the continents; became fathomless and environed with craggy rocks, cliffs, and impending shores; and its bottom spread with mountains and valleys like the land.

‘ It is further to be observed of the horrid effects of this convulsion; namely, that as the primitive islands were more ponderous and less elevated than the bottom of the sea; may we not thence infer, that the former more immediately subsided into the ocean of melted matter than the latter; and therefore became the bottom of the postdiluvian sea: and the bottom of the antediluvian sea being more elevated,

was converted into the postdiluvian mountains, continents, &c. Such were apparently the consequences arising from the convulsion of nature; and this conjecture is remarkably confirmed by the vast number of fossil shells, and other marine *exuviae*, found imbedded near the tops of mountains, and the interior parts of continents, remote from the sea, in all parts of the world hitherto explored<sup>1</sup>.—But there are many particulars, necessary for a more perfect elucidation of this interesting subject, for which I must refer to the excellent work itself<sup>2</sup>.

In this manner, and by employing a cause that appears adequate to the effect, and which is known, even at this time, partially to exist, Mr. Whitehurst accounts for the singular appearances which the present earth exhibits on and beneath its surface, for the universal deluge, and its cessation; and he does this without having recourse to comets, a sudden alteration of the earth's centre of gravity, and other violent and purely gratuitous assumptions.

It is scarcely necessary to observe, that, with respect to height, there are many sizes of mountains, from the gently-rising upland to the tall craggy precipice. The appearances are, in general, different, in those of different magnitudes. The first are clothed with verdure to their very tops, and seem to ascend merely to improve our prospects, or to supply us with a purer air: but the lofty mountains of the other class have a very different aspect. At a distance, their tops are seen, in wavy ridges, of the very colour of the clouds, and to be distinguished from them by their figure only, which, as just observed, resembles the billows of the sea<sup>3</sup>. As we approach, the mountain assumes a deeper colour:

<sup>1</sup> See No. LXXIV, On Extraneous Fossils.

<sup>2</sup> Whitehurst's Inquiry, chap. XII.

<sup>3</sup> *Lettres Philosophiques sur la Formation des Montagnes, &c.*

it gathers upon the sky, and seems to hide half the horizon behind it. Its summits also are become more distinct, and appear with a broken and perpendicular line. What at first seemed a single hill, is now found to be a chain of continued mountains, whose tops running along its ridges, are embosomed in each other; so that the curvatures of one are fitted to the prominences of the opposite side, and form a winding valley between, often of several miles in extent; and all the way continuing nearly of the same breadth.

Nothing can be finer, or more exact, than the description in my motto, of a traveller straining up the Alps. Every mountain he comes to he thinks will be the last: he finds, however, an unexpected hill rise before him; and that being scaled, he beholds the highest summit almost at as great a distance as before. Upon quitting the plain, he left, perhaps, a green and fertile soil, and a warm and pleasing climate. As he ascends, the ground assumes a more russet colour; the grass becomes more mossy, and the weather more moderate. Still, as he ascends, the weather becomes colder, and the earth more barren. In this dreary passage, he is often entertained with a little valley of surprising verdure, caused by the reflected heat of the sun collected into a narrow spot on the surrounding heights. But it much more frequently happens that he sees only frightful precipices beneath, and lakes of amazing depth, whence rivers are formed, and fountains derive their origin. On those places next the highest summits, vegetation is scarcely carried on: here and there, a few plants of the most hardy kind may be found. The air is intolerably cold; either continually refrigerated by frosts, or disturbed by tempests. All the ground here wears an eternal covering of ice, and snows that seem to be constantly accumulating. Emerging from this war of the ele-



ments, the traveller ascends into a purer and more serene region, where vegetation has wholly ceased; where the precipices, composed entirely of rocks, rise perpendicularly above him; while he views beneath him all the combat of the elements; clouds at his feet; and thunders darting up from their bosom below<sup>1</sup>. A thousand meteors, which are never seen on the plain, present themselves. Circular rainbows<sup>2</sup>; mock-suns; the shadow of the mountain projected upon the body of the air<sup>3</sup>; and the traveller's own image, reflected, as in a looking-glass, upon the opposite cloud<sup>4</sup>.

Such, in general, are the wonders that present themselves to the traveller, in his journey over the Alps, and more particularly in the Andes. But we must not suppose that this picture exhibits an invariable likeness of these stupendous heights. Indeed, nothing can be more capricious and irregular than the forms of many of them. The tops of some run in ridges for a considerable length, without interruption: in others, the line seems indented by great valleys to an amazing depth. Sometimes, one solitary mountain rises from the bosom of the plain; and sometimes extensive plains, and even provinces, as those of Savoy and Quito, are found embosomed near the tops of mountains.—But I must postpone to my next paper the further consideration of this subject, of which many interesting particulars are yet to be noticed.

<sup>1</sup> Ulloa's *Voyage to the South Sea*, vol. i. <sup>2</sup> Ibid. <sup>3</sup> *Philos. Trans.* vol. v. page 152. <sup>4</sup> Ulloa, vol. i.—For a minute, as well as picturesque, description of the various Alpine passes of the Simplon, Mont Cenis, St. Bernard, St. Gothard, &c. we refer to Mr. *Henry Coxe's Picture of Italy*, 1815; and to the *Traveller's Guide in Switzerland*, by the same author, 1816.

## No. LXXVII.

## FURTHER OBSERVATIONS ON MOUNTAINS.

Again, where Alpine solitudes ascend,  
I sit me down a pensive hour to spend ;  
And, placed on high above the storm's career,  
Look downward where a hundred realms appear ;  
Lakes, forests, cities, plains extending wide,  
The pomp of kings, the shepherd's humbler pride.

GOLDSMITH.

I CONCLUDED my former paper with a slight sketch of the variety of picturesque appearances which mountains, in general, exhibit : and these we seldom find forgotten, either in the delineations of the pencil, or in poetical description.

Sometimes the pencil, in cool airy halls,  
Bade the gay bloom of vernal landscapes rise,  
Or Autumn's varied shades imbrown the walls :  
Now the black tempest strikes th' astonished eyes,  
Now down the steep the flashing torrent flies ;  
The trembling sun now plays o'er ocean blue,  
And now rude mountains frown amid the skies ;  
Whate'er Lorraine light-touched with soft'ning hue,  
Or savage Rosa dashed, or learned Poussin drew.

THOMSON.

If we compare the heights of different mountains, we shall find that the greatest and highest are found under the line. It is thought by some, that the rapidity of the earth's motion, together with the greatness of the tides, in those parts, may have thrown up these stupendous masses of earth. But, whatever cause it may be attributed, it is a remarkable fact, that the inequalities of the earth's surface are the greatest at or near the equator. The earth, indeed, is very craggy and uneven near the

poles; but the heights of the mountains there are very inconsiderable. On the contrary, at the equator, where Nature seems to sport in the amazing size of her productions, the plains are extensive; and the mountains remarkably lofty. Some of them are known to rise three miles in height above the level of the ocean.

To enumerate the most remarkable of these, according to their size, I shall begin with the Andes, a prodigious chain of mountains, extending almost the whole length of South America, parallel with the two oceans, and terminating at the straits of Magellan. Of these mountains we have an excellent description by don Juan de Ulloa, who, by command of the king of Spain, went to Peru, in company with the French academicians, to measure a degree of the meridian. His account of his journey up these mountains is so curious, that I cannot forbear to give an extract from it.

After many days sailing up the river Guayaquil, he arrived at Caracol, a town situate at the foot of the Andes. Nothing can exceed the inconveniences he had experienced in this voyage, from the flies and mosquitos. ‘We were the whole day (says he) in continual motion, to keep them off; but at night our torments were excessive. Our gloves, indeed, were some defence to our hands, but our faces were entirely exposed; nor were our clothes a sufficient defence for the rest of our bodies; for the stings of these insects, penetrating through the cloth, caused a very painful itching. One night, in coming to anchor near a large and handsome house that was uninhabited, we were no sooner seated in it, than we were attacked, on all sides, by swarms of mosquitos, so that it was impossible to have one moment’s quiet. They who had covered themselves with clothes, made for this purpose, found not the smallest defence; wherefore, hoping to find some relief in the open

fields, they ventured on, although in danger of suffering, in a more terrible manner, from the serpents. But both places were equally ominous. On quitting this inhospitable retreat, we took up our quarters, the next night, in a house that was inhabited: the master of which being informed of the terrible manner we had passed the preceding night, told us gravely, that the house we so greatly complained of, had been forsaken, on account of its being the purgatory of a soul. But we had more reason to believe that it was quitted on account of its being the purgatory of the body. After having journeyed, upward of three days, through boggy roads, in which the mules sunk to their bellies at every step, we began, at length, to perceive an alteration in the climate: and, after having been long accustomed to heat, we now felt it grown very sensibly colder.

‘ It is remarkable, that at Taraguagua we often see instances of the effects of two opposite temperatures, in two persons happening to meet; one of them leaving the plains below, and the other descending from the mountain. The former thinks the cold so severe, that he wraps himself up in all the garments he can procure; while the latter finds the heat so great, that he is scarcely able to bear any clothes whatever. The one thinks the water so cold, that he avoids being sprinkled by it: the other is so delighted with its warmth, that he uses it as a bath.

‘ The ruggedness of the road from Taraguagua, leading up the mountain, is not easily described. The declivity is so great, in some parts, that the mules can scarcely keep their footing; and, in others, the acclivity is equally difficult. The trouble of sending people before to mend the road, the pain arising from the many falls and bruises, and the being constantly wet to the skin, might be sup-

ported, were not these inconveniences augmented by the sight of such frightful precipices, and deep abysses, as excite incessant terror. The road, in some places, is so steep, and yet so narrow, that the mules are obliged to slide down, without making any use whatever of their feet. On one side of the rider, in this situation, rises an eminence of several hundred yards; and, on the other, is an abyss of equal depth; so that, if he should give the least check to his mule, and thus destroy the equilibrium, they must both inevitably perish.

‘ Having travelled nine days in this manner, slowly winding along the side of the mountain, we began to find the whole country covered with a hoarfrost; and a hut, in which we reposed, had ice in it. At length, after a perilous journey of fifteen days, we arrived upon the plain, at the extremity of which stands the city of Quito, the capital of one of the most charming regions in the world. Here, in the centre of the torrid zone, the heat is not only very tolerable, but, in some places, the cold is even painful. Here the inhabitants enjoy all the temperature and advantages of perpetual spring; the fields being constantly covered with verdure, and enamelled with flowers of the most lively colours. However, although this beautiful region be more elevated than any other country in the world, and it took up so many days of painful journey, in the ascent, it is overlooked, nevertheless, by tremendous mountains: their sides covered with snow, while their summits are flaming with volcanos. These mountains seem piled one upon the other, and rise to an astonishing height, with great boldness. However, at a determined point above the surface of the sea, the congelation is found at the same height in all the mountains. Those parts which are not subject to a continual frost, have here and there growing upon them a rush, resembling the *genista*



or broom, but much softer and more flexible. Toward the extremity of the part where the rush grows, and the cold begins to increase, is found a vegetable with a round bulbous head, which, when dried, has an amazing elasticity. Higher still, the earth is entirely bare of vegetation, and seems covered with eternal snow. The most remarkable of the Andes are the mountains of Cotopaxi<sup>1</sup>, Chimborazo, and Pichincha. On the top of the latter was my station for measuring a degree of the meridian; where I suffered particular hardships from the intenseness of the cold, and the violence of the storms. The sky around us in general involved in thick fogs, which, when they cleared away, and the clouds, by their gravity, moved nearer to the surface of the earth, appeared surrounding the foot of the mountain, at a vast distance below, like a sea, encompassing an island in the midst of it. When this happened, the horrid noises of tempests were heard from beneath, then discharging themselves on Quito and the neighbouring country. I saw the lightning issue from the clouds, and heard the thunders roll far beneath me. All this time, while the tempest was raging below, the mountain top, where I was placed, enjoyed a delightful serenity<sup>2</sup>. The wind was abated, the sky clear, and the enlivening rays of the sun moderated the severity of the cold. However, this was of no very long duration; for the wind returned with all

<sup>1</sup> This mountain is more than three miles above the surface of the sea. It is a celebrated volcano, one of the eruptions of which is described in Ulloa's Voyage, vol. i. p. 442. Vesuvius, and even Ætna, it should be observed, are mere fire-works, compared to the volcanos of the Andes, which, as they are the highest mountains in the world, are the most formidable also for their eruptions. On this subject the inquisitive reader should peruse *Humboldt's Travels in South America*, for the most recent and correct information.

<sup>2</sup> Some of my readers may here recollect Dr. Young's Character of a Good Man, in his eighth Night; in which one

its violence, and with such velocity as to dazzle the sight; while my fears were increased by the dreadful concussions of the precipice, and the fall of enormous rocks; the only sounds that were heard in this frightful situation.

In comparison with the dangerous ascent thus described by the Spanish philosopher, a passage over the Alps, and a journey across the Pyrenees, appear only *excursions*. These are the most lofty mountains in Europe; but the Alps are little more than one half the height of the Andes, of which one (Chimborazo), we know, from geometrical and barometrical mensurations, is 20,280 feet above the level of the sea. But lofty as are the highest mountains on the earth, it has been demonstrated, that they are nothing compared to its prodigious magnitude. For instance, what proportion the thickness of a human hair bears to a globe eighty inches diameter, the same does a mountain, a quarter of a mile high, bear to the whole globe<sup>1</sup>.

Mountains appear, to many, defects and blemishes in the earth; but they are certainly of the greatest service to the well-being both of man and other animals. Many creatures cannot live but in particular situations; and even the tops of the highest and coldest mountains are the only places where some creatures will live: of this kind are the ibex and chamois among quadrupeds, and the lagopus among birds.—They serve as skreens to keep off the cold

would imagine that he had either copied, or anticipated, the description here given by the ingenious Spaniard:

With aspect mild, and elevated eye,  
Behold him seated on a mount serene,  
Above the fogs of sense, and passion's storm;  
All the black cares and tumults of this life,  
Like harmless thunders, breaking at his feet,  
Excite his pity, not impair his peace.

<sup>1</sup> Whitehurst's Inquiry, ch. xii.

blasts of the northern and eastern winds. They also serve for the production of several vegetables and minerals which are not found in any other soil : they enable us to keep those mines dry which furnish the most useful metals. Besides, the long ridges and chains of lofty mountains being generally found to run from east to west, serve to stop the evagation of the vapours toward the poles, without which they would all run from the hot countries, and leave them destitute of rain. Mr. Ray adds, that they condense those vapours, like alembic heads, into clouds ; and thus, by a kind of external distillation, give origin to springs and rivers ; and by amassing, cooling, and condensing them, turn them into rain, and thus render habitable the fervid regions of the torrid zone. The supply, moreover, which they give to springs and rivers, by stopping and condensing the clouds, is rendered more copious still by the prodigious quantities of snow by which their summits are crowned. This last circumstance in particular, is noticed by our philosophical poets :

When mid the lifeless summits proud  
Of Alpine cliffs, where to the gelid sky  
Snows piled on snows in wint'ry torpor lie,  
The rays divine of vernal Phœbus play ;  
Th' awakened heaps, in streamlets from on high,  
Roused into action, lively leap away,  
Glad warbling through the vales, in their new being gay,

THOMSON.

Thus on the soil with heat immoderate dried,  
To which the rain's pure treasures are denied,  
The mountains more sublime in ether rise,  
Transfix the clouds, and tower amid the skies ;  
The snowy fleeces, which their heads involve,  
Still stay in part, and still in part dissolve ;  
Torrents and loud impetuous cataracts  
Through roads abrupt, and rude unfashioned tracts,  
Roll down the lofty mountain's channelled sides,  
And to the vale convey their foaming tides ;  
At length, to make their various currents one,  
The congregated floods together run ;

These confluent streams make some great river's head,  
 By stores still melting and descending fed;  
 Thus from th' aspiring Mountains of the Moon<sup>1</sup>,  
 Dissolving treasures rush in torrents down,  
 Which pass the sun-burnt realms and sandy soil,  
 And bless th' Egyptian nation with their Nile:  
 Then whoso'er his secret rise would know  
 Must climb the hills, and trace his head in snow;  
 And through the Rhine, the Danube, and the Rhone,  
 All ample rivers of our milder zone,  
 While they advance along the flats and plains,  
 Spread by the showers augmented, and the rains;  
 Yet these their source and first beginning owe  
 To stores, that from the Alpine mountains flow;  
 Hence, when the snows in winter cease to weep,  
 And undissolved their flaky texture keep,  
 The banks with ease their humble streams contain,  
 Which swell in summer, and those banks disdain.

BLACKMORE.

But the benefit of mountains, in general, is not only, that vapours driven against them are condensed, so as to be precipitated through the chinks of the rocks, but that afterward, in their bowels, they are preserved, till they form rivulets, and then rivers. Vapours would fall in rain or dew, although there were no mountains; but then they would fall equally, over considerable places of the globe at once, and thus would be sucked deep in the ground, or make a universal puddle. On the contrary, by means of mountains, they are perpetually pouring down in particular places, and treasuring up a constant supply to the rivers. Another considerable use of them is the determination of these rivers; for if there could have been rivers without mountains, yet they could have flowed in a straight line only, if they had flowed at all; whereas, by these eminences placed up and down, they make innumerable turnings and windings, by which they water and enrich the soil of many different countries in one

<sup>1</sup> Mountains in Africa so called.

course, and at last disembogue, sometimes in several mouths, into the sea. But, not to be too diffusive, I shall conclude, with observing, that these stupendous masses are not, as some have supposed, mere incumbrances of the creation, or rude and useless excrescences of the globe, but in a variety of instances, add greatly to its beauty, and answer many excellent purposes. In a word, when we contemplate the mountains among the other innumerable displays of the goodness, wisdom, and omnipotence of the Universal Creator, well may we exclaim with the prophet Habakkuk, ‘*The everlasting mountains were scattered—His ways are everlasting;*’ or in the sublime personification of the Psalmist, ‘*Mountains and all hills—praise the name of the Lord; for his name alone is excellent; his glory is above the earth and heaven.*’

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## No. LXXVIII.

## THE CONCLUSION.

The whole up-tracing, from the dreary void,  
The chain of causes and effects, to Him,  
The world-producing Essence, who alone  
Possesses being.

THOMSON.

IN the conduct of the Contemplative Philosopher, of which this number is the conclusion, I have wandered into some of the most fertile regions of philosophical discussion, and collected a variety of the wonderful phenomena of Nature, as rational subjects of curiosity and investigation. My young



readers, in particular, I have endeavoured to allure to these improving inquiries, by strewing, as it were, each winding path with flowers, showing, at the same time, how much some of the finest passages in poetry are indebted, for their beauty, to the gay and lively, or to the sublime, and even terrific images, which are every where so profusely scattered. But I have deemed this a consideration of infinitely less moment, than that of inculcating the principles of piety and virtue, by occasionally introducing such religious and moral reflections as each subject had a tendency to inspire; and pointing out, as the glorious theme of all, the irresistible indications of a Supreme Being, the Great Creator and Governor of Universal Nature.

Ere the rising sun  
Shone o'er the deep, or 'mid the vault of night  
The moon her silver lamp suspended: ere  
The vales with springs were watered, or with groves  
Of oak or pine the ancient hills were crowned;  
Then the Great Spirit, whom his works adore,  
Within his own deep essence viewed the forms,  
The forms eternal of created things:  
The radiant sun; the moon's nocturnal lamp;  
The mountains and the streams: the ample stores  
Of earth, of heaven, of Nature. From the first,  
On that full scene his love divine he fixed,  
His admiration. Till, in time complete,  
What he admired and loved his vital power  
Unfolded into being. Hence the breath  
Of life informing each organic frame:  
Hence the green earth, and wild resounding waves:  
Hence light and shade, alternate; warmth and cold;  
And bright autumnal skies, and vernal showers,  
And all the fair variety of things. AKENSIDE.

It is observable, that however opposite are the hypotheses of Atheism and Theism, there is one common circumstance in which they agree; and that is, that something must have been, from all eternity, self-existent and independent. But the

Atheist asserts, that this visible material universe is that necessarily existing something. His opinion, therefore, is, that as there is an infinite variety of beings in the universe, and a great diversity of qualities, faculties, and perfections appertaining to the several kinds of them, yet, that the very lowest of all, namely, senseless passive matter, must be the first principle, the eternal self-existent being, from which, as the sole independent origin, all things, even the most regular and beautiful, arose; together with the highest perfection of understanding, virtue, and felicity, without any active, intelligent, designing cause. But this hypothesis is incumbered with insurmountable difficulties; for it can account for nothing in the whole visible creation, without attributing it to what is in itself nothing, Necessity, or Chance. Neither of these can account for the beautiful order, proportion, and harmony, so visible in the whole creation; nor for the formation of animal life in such variety of species, all preserved distinct from each, without confusion, and propagated by a settled law—each fitted to its own element, provided with proper food for subsistence, and proper means for procuring it; with suitable instincts and organs, particularly sensation and self-motion, the principal appearances of the sensitive life. Nor is it possible, moreover, on the atheistical hypothesis, to account for conscious intelligence, which it diminishes into a vain and empty shadow, the accidental result of the figure of matter and motion; although, as it is this very conscious intelligence that makes man *himself*, nothing can appear to him more real and substantial.

But the doctrine of a Deity and a Providence is absolutely the reverse of this, and explains the system of the universe in a consistent and satisfactory manner. It represents intelligence as the first of things, the cause and origin of all derived beings; and, by the aid of this representation, all things appear in a

beautiful and amiable light. A supreme, eternal, self-existent mind, immutably possessed of all absolute perfections, formed the plan of universal creation, and finished it according to his own perfect model; the unceasing object of admiration to those superior minds, who endeavour to improve their intellectual and moral powers, and, by the study of Nature and of Nature's God, to rise to the most sublime heights of science and of virtue<sup>1</sup>.

It was, indeed, to be expected, that the work of a Divine Architect should bear the signature of his hand; that his infinite goodness, and wisdom, and power should be displayed in the magnificence and variety, the beautiful proportion and exquisite harmony of the whole. The entire mass of extended passive matter, in itself so mean and contemptible, is formed into various beauty, by the energy of spirit that pervades it. Hence there is a gradual ascent to the utmost heights of excellence; and in every rising step of the scale we behold a growing display of original perfection. Vegetation itself is a wonderful improvement upon dead matter; but animal sensation and spontaneous volition, however low in comparison, are strong images of understanding and activity. Human intelligence, with its various powers, exercises, and enjoyments, is the highest in our world, and leads us directly to the Great Original, the Uncreated Mind, by which it was formed. Between these two there seems to be an immense chasm; but we have reason to imagine, that there are intermediate orders of celestial beings, superior to us; although the most exalted of them must ever be at an infinite distance from unoriginated excellence.

In the various subjects of my preceding papers, the reader must have observed many striking instances, in which the wisdom and contrivance of a

<sup>1</sup> See some beautiful lines on this subject in p. 218.

supreme directing power were too evident to be denied. In the productions of an infinite mind, much, however, must remain for ever incomprehensible by the most enlightened mortal. This, so far from being an argument against the existence of contrivance and design in every thing we see, demonstrates only the infinite distance between the underrived source of all perfection, and the most exalted excellence of which human understanding can form a conception. *Can we by searching find out God? Can we find out the Almighty unto perfection?*<sup>1</sup> Yet, although unsearchable his nature, and inscrutable his ways, enough is known to excite the most awful sentiments of wonder and adoration. *For the invisible things of Him, who dwelleth in unapproached light<sup>2</sup>, even his eternal power and godhead, are clearly seen, being understood by the things that are made<sup>3</sup>. The heavens declare His glory, and the firmament sheweth His handy work. Day unto day uttereth speech, and night unto night sheweth knowledge<sup>4</sup>.*

But I have already expatiated upon this sublime subject<sup>5</sup>, and the limits of this paper will not permit me to attempt a more copious discussion. Nothing can be more improving than frequent meditations on this inexhaustible theme; nothing more instructive than inquiries into the general laws of nature: provided, after all, that the result of our researches be not the mere gratification of useless curiosity, or enlargement of the sources of unprofitable amusement, but a deep sense of the infinite wisdom and power of the Supreme Being; the cultivation of those devout affections which a grateful sense of his unceasing goodness should inspire; a sincere and steady obedience to his holy laws, in the unaffected exercises

<sup>1</sup> Job xi. 7.<sup>2</sup> Par. Lost, iii. 4. and 1 Tim. vi. 16.<sup>3</sup> Rom. i. 20.<sup>4</sup> Psalm xix. 1.<sup>5</sup> See No. vi.

of piety, the practice of all the moral virtues, and, more particularly, the delightful sentiment of benevolence, from our own small domestic circle, expanding and expanding, till it include the whole human race. Nor should a religious acquiescence in all the divine dispensations be forgotten: it will naturally spring from a firm and well-grounded confidence in the over-ruling providence of God: it will fill the mind with consolation in calamity, with serenity in the more prosperous scenes of life, with fortitude in sickness, and with peace, and hope, and joy, even in the moment of dissolution. But the habits of piety and virtue must be formed, not by a few momentary and transient sentiments, but by serious and frequent meditations on such subjects; and I would fain adopt myself, and wish all my readers to adopt, the charming sentiment of the poet of the Seasons:

For me, when I forget the darling theme,  
Whether the blossom blows, the summer ray  
Russets the plain, inspiring autumn gleams,  
Or winter rises in the blackening east,  
Be my tongue mute, may fancy paint no more,  
And, dead to joy, forget my heart to beat.



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